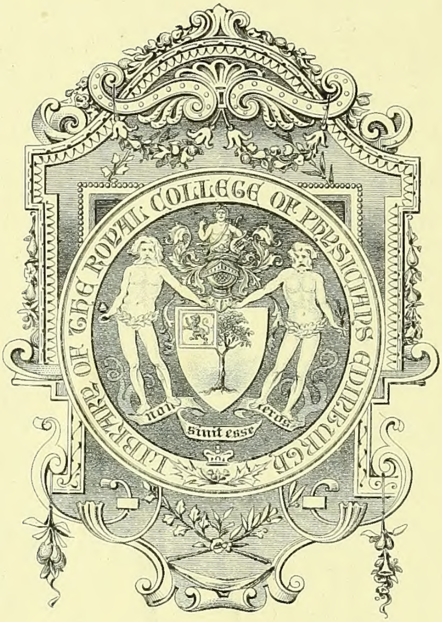
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A Manual of Surgical Treatment

BY

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NEW EDITION

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TO

THE RIGHT HON.

LORD LISTER, O.M., LL.D., F.R.S.

THE FOUNDER OF MODERN SURGERY

WITHOUT WHOSE WORK MUCH OF THIS BOOK

COULD NOT HAVE BEEN WRITTEN.

PREFACE

TO

REVISED EDITION.

SINCE the first edition of this work was published many changes have naturally occurred in the field of Surgical Treatment. Attempts have been made from time to time to incorporate the most essential of these in successive impressions, but it is always difficult to interpolate new matter of this kind satisfactorily without extensive revision of the entire work. It has therefore seemed best to revise the matter throughout and to alter in it whatsoever was necessary to bring it up to date. The original scheme of the work has been adhered to; to depart from it would have been to abandon the fundamental idea upon which it was based. Every part of the book, however, has been thoroughly revised, and a considerable part has been re-written.

The pressure of other work rendered it impossible for the original authors to undertake a task of such magnitude with any hope of being able to complete it within a reasonable time. In Messrs. T. P. Legg and Arthur Edmunds they have been fortunate in securing collaborators who have rendered their task possible, and to them they are under a great obligation. To their colleagues Dr. Silk, Dr. D'Este Emery, Dr. Arthur Whitfield and Mr. A. D. Reid, they are also much indebted for help in the several departments of treatment with which these gentlemen are specially concerned. Mr. Arthur Edmunds, in addition to his share in the revision, has provided a number of the new illustrations; Messrs. F. Butterworth and S. A. Sewell have drawn the remainder.

Messrs. Down Bros., Allen & Hanburys, Barth, and others have kindly allowed the reproduction of many instrument blocks from their catalogues. Other figures have been reproduced by permission of their authors or publishers, and the source from which they are derived will be found duly acknowledged in the text.

LONDON, 1911.

AUTHORS' PREFACE

TO

THE FIRST EDITION.

THE subject of Surgery has now become so extensive that any work attempting to deal with it in an exhaustive manner must necessarily be so large and unwieldy as to be suitable only for purposes of reference, or for the use of those who devote themselves exclusively to its practice. In any text-book of convenient size the information given in certain branches of the subject must therefore be considerably condensed, and, as the first essential for the beginner is to have the fullest knowledge of the nature and characters of the diseases that he has to study, special stress is usually laid upon pathology, symptomatology, and diagnosis. For the practitioner, on the other hand, who is already acquainted with these points, the great essential is full and detailed information as to the best methods of treatment.

We have ourselves frequently experienced the want of detailed information, especially as regards the after-treatment of our cases, and have had to learn the best methods of procedure from experience. Nothing can of course replace experience, but it is often of the greatest advantage to have a detailed record of that of others upon which to base one's work. It is this want that the present work is intended to supply. We have tried to put ourselves in the place of those who have to treat a given case for the first time, and we have endeavoured to supply them with details as to treatment from the commencement to the termination of the illness. We have assumed that the reader is familiar with the nature and diagnosis of the disease, and we only refer to the pathology and symptoms in so far as it is necessary to render intelligible the principles on which the treatment is based, and the various stages of the disease to which each particular method is applicable.

We have purposely avoided attempting to give anything like a complete summary of the various methods of treatment that have from time

to time been proposed: to do so would merely confuse the reader. Only those plans are described which our experience has led us to believe are the best, but with regard to these we have endeavoured to state exactly and in detail what we ourselves should do under given circumstances. In some cases no doubt several methods of treatment are of equal value, and while we have discussed at length that which we have ourselves been led to adopt, we have referred shortly to the others.

We have not mentioned all the exceptional conditions that may be met with, but we have endeavoured to include all the circumstances with which the surgeon is most commonly called upon to deal. The task has been one of some difficulty, the more so as we have had, to a certain extent, to break new ground. This must serve as our excuse for the many shortcomings in the work.

LONDON, *April*, 1899.

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DIVISION I.

THE SURGICAL AFFECTIONS OF THE SOFT TISSUES.

CHAPTER I.

AFFECTIONS OF THE SKIN AND SUBCUTANEOUS TISSUES.

BLISTERS.

THESE as a rule are of little moment, especially if properly treated, but they may give rise to great inconvenience when they occur on the feet, and may prevent the patient from walking; this happens more especially in the case of soldiers, policemen, etc. On the feet they occur about the heel, the instep, or the toes. A blister is of importance partly from the physical pain in walking caused by the irritation of exposed nerve ends, and partly from the susceptibility to septic infection, lymphangitis, cellulitis, etc., that has always to be reckoned with in these cases.

TREATMENT.—The **prophylactic treatment** in the case of soldiers and others subject to blisters must not be neglected; it consists mainly in observing scrupulous cleanliness of the feet, and avoiding tight or too loose boots, or undue pressure or friction on any one particular part; a further precautionary measure, which it is well to employ before a long march, is to rub the feet well with fat or tallow. The feet may also be bathed in methylated spirit or whisky before greasing them.

When blisters have occurred the best plan is to puncture them at their most dependent part after having washed them well with 1 in 20 carbolic lotion, so as to disinfect the surface. After the fluid they contain

has escaped, suitable measures must be taken to prevent any further friction, so that the separated epithelium may remain in contact with the raw surface beneath and protect it against external sources of irritation. If possible, rest should be enforced. When the epithelial layer has been detached, some simple antiseptic application, such as dilute boric ointment (one-fourth of the B.P ointment), should be employed.

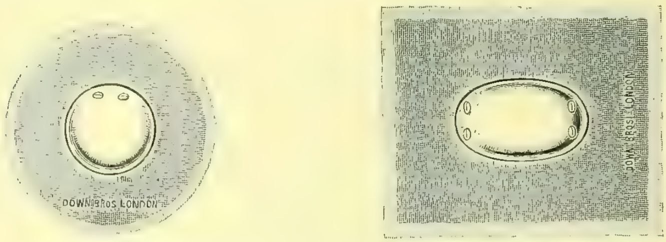


FIG. 1.—CELLULOID SHIELDS. The shield is inserted in the centre of a sheet of adhesive plaster, by which it is applied to the limb. The holes in each shield are to permit of evaporation.

When the patient is compelled to get about, some form of hollow pad designed to keep the pressure off the blister should also be provided. When it is merely necessary to prevent the surface of the blister from being irritated by the clothes, a very useful method in parts other than the feet is to protect the raw area by means of a perforated convex celluloid shield (see Fig. 1) fastened over the part by strapping. These shields are of various shapes and sizes ; the dressing to the blister lies in the shield and is kept in place by it.

CALLOSITIES.

These are indurated, prominent yellowish portions of skin, shading off at their edges, and consisting essentially of thickening of the horny layer of the epidermis. They are due to repeated friction and may be preceded by blisters. Relief of the pressure will lead to disappearance of the callosity, but while it lasts the callosity is often extremely painful, and a bursa may form beneath it and become inflamed or suppurate.

TREATMENT.—When the callosity is causing pain, it is well to shave off as much of the thickened epidermis as possible, after softening it by prolonged soaking in water as hot as can be borne, and then to apply *salicylic collodion* (100 grains of salicylic acid to the ounce of flexile collodion) and to repeat this application night and morning. This should be combined with the use of a *hollow pad* to prevent pressure, which may consist of thick felt plaster. The pad should overlap the thickened area for three-quarters of an inch in all directions, and a hole corresponding in size to the callosity should be cut in its centre. This treatment will usually lead to the disappearance of the affection.

CORNS.

Corns are small localised hypertrophies of the epidermis, the peripheral part consisting of a number of layers of parallel epidermic cells, and the central portion being formed by a dense mass which presses on the papillæ and the dermis, and causes more or less atrophy of these structures. Not infrequently a small bursa forms beneath the centre of the corn, and, if the irritation persist, inflammation and suppuration may occur in it, and the condition thus produced is known as a suppurating corn. Corns are met with where there is long-continued but intermittent pressure, and are frequently found between the toes.

TREATMENT.—Absolute cleanliness must be insisted upon. The part must be kept dry, and pressure on any prominent points avoided. Pointed shoes must be especially eschewed as they compress the feet, and constantly lead to the occurrence of corns both between the toes and over the more prominent points, especially the outer side of the little toes. When a corn has formed, all pressure should be taken off it, and not infrequently the *avoidance of pressure* alone is sufficient to lead to the separation of the dense core and to a complete disappearance of the trouble. Pressure may be avoided in various ways ; when the corn is situated between two adjacent toes, a piece of boric lint inserted between them, so as to prevent them pressing on one another, will relieve the pressure and so bring about a cure. In the sole, pressure is best relieved by a *hollow ring-pad*, the corn being made to occupy the centre of the ring. The disappearance of the corn may be much accelerated by *paring down the dense core* with a razor, after the toe has had a prolonged soaking in hot water. In paring down the thickened epidermis care must be taken not to go deep enough to injure the living tissues, because the epidermis of a corn often contains much septic material which may be introduced through the incision in the skin and lead to serious infection.

As a rule, after the source of pressure has been removed and the corn has been pared several times, it is not difficult to pick out its core with a needle, when the skin of the part will very soon resume its normal appearance if further pressure be avoided. When the corn is large, it is well after paring it to apply *salicylic collodion* (*vide supra*) once a day, repeating the paring if necessary about once a week ; if the corn be situated between the toes, care must be taken to keep the latter well apart until the collodion is thoroughly dry. Some arrangement for preventing pressure subsequently must be also employed.

When there is a **suppurating corn** the patient should be made to lie up, and the *abscess opened* with a Syme's abscess knife by an incision through the centre of the corn. The pus usually forms in the bursa beneath the base of the corn, and, though only small in amount, may.

B 2

from the tension under which it is, cause exquisite pain long before it gives rise to fluctuation or any other characteristic sign of an abscess. When the corn has been cut through, and the pus let out, the relief is immediate. The entire corn, which is undermined by the abscess, should then be clipped away with scissors, and warm boric fomentations applied; they should be changed frequently and continued until all acute symptoms have subsided, when dilute boric ointment may be substituted. This small operation, which ends in the permanent cure of the corn, is best done under nitrous oxide; local anæsthesia is not to be recommended.

INFLAMMATORY AFFECTIONS.

Of these, multiple acute abscesses, boils, and carbuncles demand consideration; there are, in addition, various specific inflammatory conditions of the skin which must be noticed. The more diffuse inflammatory affections, such as acne, lichen, etc., do not properly belong to this group of surgical affections of the skin.

MULTIPLE ACUTE ABSCESSES OF THE SKIN AND SUBCUTANEOUS TISSUE.

This affection is not uncommon in infants and young children. The abscesses probably occur in connection with the sebaceous glands, and are principally due to dirt, eczema, scratching, etc. In infants they are often the result of dirty flannel being in constant contact with the skin, so that, as the child wriggles, the dirt from it is rubbed into the orifices of the glands. In infants the skin is thin and soft, and sloughing does not occur so readily as in the harder skin of adults, and hence acute inflammation of the skin in them leads to the formation of acute abscesses, which take the place of boils in adults. In morphinomaniacs similar abscesses are common.

TREATMENT.—This is similar to that of abscesses generally. Any abscesses present should be opened freely with full antiseptic precautions (see Vol. I. p. 27), and the further spread of the trouble should be provided against by thoroughly cleansing the skin, and disinfecting it with special care in the vicinity of the abscesses. The use of clean underlinen or flannel must be insisted on. The subsequent use of Wright's vaccine method (*vide infra*) may be of value.

BOILS.

Boils are closely related, as far as their seat of origin is concerned, to acne and impetigo, the latter being a pustular eruption of the skin in

connection with the hair follicles, and a boil being a circumscribed gangrenous inflammation of the skin which probably occurs in connection with the sebaceous glands of the same structures. Boils are small conical, hard and painful swellings, which usually suppurate and give exit to a soft slough, in which are the remains of the hair and the sebaceous structures. They chiefly occur where the hairs are coarse and the sebaceous glands are numerous (with the exception of the hairy scalp), and they are especially frequent on parts which are subject to friction. The organism usually found in them is the staphylococcus pyogenes aureus.

In the early stage of a boil there is a small swelling, in the centre of which appears a vesicle containing rusty-coloured fluid ; from the middle of this a hair generally protrudes. In three or four days the boil develops into a bright red, somewhat conical swelling, which may at this time abort ; if it does not, it increases in size, its apex becomes yellow from the presence of pus, and finally perforation occurs, and the pus escapes. At the bottom of the opening thus formed is a yellowish slough, which is usually cast off about the eighth day, and then healing occurs rapidly.

PROGNOSIS.—This is favourable except when some constitutional disease, such as diabetes, is present, or when the affection occurs on the face or the lip, in which case it may be followed by serious septic troubles. Lymphangitis and inflammation of the neighbouring glands are common, while phlebitis, septicæmia, pyæmia, and erysipelas occasionally follow, especially in the case of boils on the face. A boil is often followed by others in the vicinity from local infection, the pus from the original boil being rubbed into the skin by the friction of the clothes. Sometimes cases of persistent furunculosis are met with. Here the tissues appear to possess an abnormally low resistance to the staphylococcus, and fresh crops of boils are continually arising in different parts.

TREATMENT.—**Local.** In the early stage a boil may abort if it be left alone and shielded from injury. After the skin has been disinfected, the surface of the boil should be painted with *flexile collodion* every day, and friction avoided, if necessary, by the employment of a *shield*. The best form of shield is one made of celluloid (see Fig. 1), of sufficient size to protect the inflamed area without pressing on it. If there be much pain, warm boric fomentations may be applied beneath the shield. At the same time, general treatment (*vide infra*) should be employed.

With the view of preventing the appearance of fresh boils due to direct infection, steps should be taken from the first to *disinfect the skin in the vicinity* of the boil, so as to get rid of any infective material that may have soaked into it. The skin around the boil should be shaved and disinfected, and then an antiseptic

ointment[1] should be smeared over it, so as to destroy any cocci that may remain on the skin. The latter should be thoroughly cleansed once or twice daily with ether soap and 1 in 2000 sublimate solution, and the ointment should be renewed after each washing. Friction by the clothes must be avoided ; for example, collars should be left off and soft shirts worn when the boil is on the neck. When the boils are on the body or limbs it is well to have the underclothing changed daily, and to see that the underclothing left off is sterilised by boiling.

If the boil does not abort, as will become evident about the fourth day, *antiseptic compresses* such as boric fomentations or the following lotion : Hydrarg. Salicyl., gr. iij ; Acid. Salicyl., gr. xx ; Spts. Vini Rect. ℥i, Aquam ad ℥iv, may be employed ; but if the pain be very severe, *early crucial incisions*, dividing the brawny tissues completely across, will give more relief than any other plan. It must not be supposed, however, that much quicker healing will be obtained by early incision, unless means be taken to get rid of the slough at the same time. Whether incisions be made or not, the slough will not separate before about the eighth day, but the advantage of the incision is that it ensures relief of the pain and a diminution of the inflammatory trouble. When a boil is bad enough to call for incision, the best plan is to *scrape out the slough* with a sharp spoon, if it be at all loose, and then to apply *undiluted carbolic acid* to the cavity left.

FIG. 2.—BIER'S SUCTION CUP AS USED FOR BOILS. The glass rim is applied firmly over the boil—or small carbuncle—after the air has been squeezed out of the india-rubber ball. If the edge of the glass be smeared with vaseline, good suction will be exerted on releasing the pressure upon the india-rubber ball.

Bier's suction method (see Vol. I. p. 14) and Wright's method of vaccine treatment (see Vol. I. p. 514) may often be employed with advantage. It is in cases of frequently recurring boils that the most striking effects have been obtained by the use of vaccines, but care must be taken as regards the dosage, otherwise disastrous results may follow.

After-treatment.—If the slough be got away completely, the best dressings afterwards are *antiseptic ointments*, such as eucalyptus, or boric ointment, changed twice a day, the wound and the parts around being washed with a 1 in 2000 sublimate solution each time the dressing is renewed. If portions of the slough still remain adherent, *boric fomentations* should be employed until they have separated.

[1] A useful ointment is composed of :

Acid salicyl.	gr. xx.
Ichthyol	ʒ ss.
Ung. hydrarg. oleat. (5%)	℥ j.
Zinci oxidi } Amyli }	ãã ʒ ij.
Paraffini mollis	℥ ss.

The **general treatment** must also be attended to. The *urine must be tested* for sugar or albumen, and, if either be present, suitable constitutional treatment must be adopted. The *bowels* should be kept freely open by saline aperients, and *iron* (tinct. ferri perchlor., 15 to 25 minims

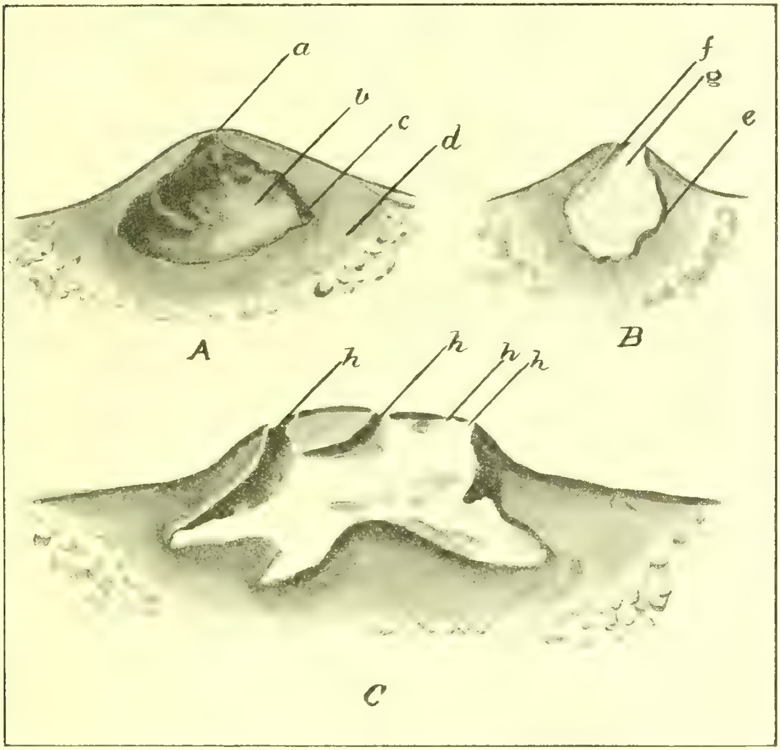


FIG. 3.—DIAGRAMMATIC SECTION OF ACUTE INFLAMMATORY AFFECTIONS OF THE SKIN. *A. An acute abscess*: *a*, the point where the suppuration has reached the horny layer of the skin—the pointing of the abscess; *b*, the abscess cavity; *c*, the abscess wall merging into *d*, the surrounding mass of acutely inflamed tissue. *B. A boil*: The opening through the skin *f*, exposes a massive slough *g*, around which there is merely a narrow chink containing pus *e*. *C. A carbuncle*: The condition resembles *B*, but there are many points *h h h h* at which the skin is perforated.

in water every six hours, or 10 grains of Blaud's pill three times a day) should be given. Stimulants may be required in weakly subjects.

CARBUNCLE.

A carbuncle is a gangrenous inflammation of the skin and subcutaneous tissues affecting a considerable area, and is essentially a number of boils aggregated together. In the initial stage there is a large brawny rusty-coloured swelling in the skin, looking just like an exceedingly large boil, but on the third or fourth day numerous small pustules begin to

appear on the surface of the carbuncle, and in two or three days more these burst and leave openings exuding pus ; at the bottom of each a white slough is seen. If the case be untreated and the patient survives, the skin between the various openings sloughs to some extent, and thus a sufficiently large aperture is formed to allow of the escape of the deeper-seated slough. During this process, however, the constitutional disturbance is often severe, and patients are liable to fall victims to general septic infection.

Carbuncles occur most frequently in males over forty, and usually in parts where the skin is thick, as on the back. They are due to the same organism as boils, and often originate in connection with some local irritation, such as friction by the clothes, or want of cleanliness. The general condition plays a greater part in the production and course of carbuncles than it does in the case of boils, and thus carbuncles occur chiefly in cachectic or half-starved people, in drunkards, and notably in those suffering from diabetes. As regards the latter affection, it may be mentioned that sugar may appear in the urine during the course of a carbuncle, and may subsequently disappear when convalescence takes place. It is important, therefore, not to mistake this temporary glycosuria for true diabetes. The carbuncle in the diabetic is usually situated on the back of the neck, and is a very grave disease, as the patient often dies from diabetic coma, and is specially liable to septic infection elsewhere ; moreover, this form of the disease is sometimes slow and insidious in the early stages, and there is not the violent swelling seen in the ordinary form, the pain and the fever being only moderate in degree. If the case be left to itself, and the patient live, it usually takes at least two months before the wound heals.

PROGNOSIS.—This depends on the size of the carbuncle, and the presence or absence of complications. In large carbuncles the prognosis is bad.

TREATMENT.—**General Treatment.**—*Opiates* are always called for, partly to enable the patient to obtain sleep, and partly to diminish the amount of sugar when present ; *codeine*, in doses of a quarter to half a grain every four hours, is better than opium in diabetic cases. In addition, *tonics* should be administered, especially *iron* (*e.g.* pil. ferri redacti gr. iij, or tinct. ferr. perchlor. ♏ xv-xxv in water three times daily). The patient's strength must be supported by the free administration of *liquid food* ; if sugar be absent from the urine, three or four pints of milk should be given daily, along with raw meat juice.

If diabetes be present, *codeine* should be given, and the patient dieted. When there is great weakness, it is not judicious to restrict the diet too much, but the use of sugar and starchy substances should be limited as far as possible, and as time goes on and the patient improves, the diet may be made more strict (see Vol. I. p. 80). Should the patient be passing into a typhoid state, *stimulants* should be used freely.

Local Treatment.—Before the appearance of the pustules on the surface of the carbuncle, and before the symptoms are very severe, warm fomentations may be employed in the hope that the inflammation may subside, or, at any rate, that its extent may be limited by their use. But when suppuration is evident, operation must be carried out. The operative procedures are excision, incision combined with scraping, or free incision alone.

Excision.—The best treatment for a carbuncle of moderate size is to make an incision completely encircling it, and to dissect it out cleanly under general anæsthesia, using full antiseptic precautions. Nothing is lost by excision, because the skin over the carbuncle is of little use in the subsequent healing, whilst the subcutaneous tissues will certainly slough, so that there is no extra loss of tissue. On the other hand, early removal may cut short the whole trouble, and free the patient from the pain, from the danger of extension of the disease, and from the risk of general septic infection. The excision must be quite clean, and must be well beyond the limit of the disease, or else local recrudescence is almost certain.

In order to diminish the risk of infection of the wound it is well to sponge the surface of the skin to be removed with undiluted carbolic acid. The incision generally requires to be carried down to the deep fascia ; the amount of blood lost is not great, the oozing that occurs being readily stopped by pressure, aided by adrenalin if necessary in feeble subjects. After removing the affected area and arresting the oozing, it is well to sponge the surface of the wound with undiluted carbolic acid, and then to apply cyanide gauze dressings. As soon as it is certain that the raw surface has not become infected and is granulating healthily, *skin-grafting* (see Vol. I. p. 54) should be employed.

Incision and Scraping.—When the affection is very extensive, and when the patient is so enfeebled that the loss of blood entailed by excision would be serious, the foregoing method is not advisable, and free crucial incisions must be made into the carbuncle instead. These incisions should extend right across the affected area, from the healthy skin on one side to the healthy skin on the other, and must divide the sloughs throughout their entire depth. These should then be cut or scraped away as thoroughly as possible ; and if the whole slough can be removed in this manner, the chief risk of the disease will be disposed of. All the perforated and undermined skin should also be cut away ; it can do no good, and only forms a possible source of fresh infection of the wound afterwards. When the slough has been got rid of as thoroughly as possible, the bleeding should be arrested, and the raw surface impregnated with *undiluted carbolic acid*. The object of this is to disinfect any portion of the slough that may remain, and to kill any organisms that may have penetrated into the tissues beyond the sloughing area, for, in scraping a carbuncle, there is a certain risk that the organisms may be pressed into

the cellular tissue and the lymph spaces around, and thus set up fresh trouble. The skin around the affected area should be disinfected both before the operation is commenced and after the part has been scraped out, because the sloughs and pus from the interior are otherwise certain to re-infect the skin. The wound should be packed with *moist cyanide gauze* sprinkled with *iodoform*. Care must be taken not to use too much of this drug, because it may give rise to toxic symptoms ; surfaces impregnated with undiluted carbolic acid absorb iodoform more readily than those which have not been so treated.

After-treatment.—The gauze packing is changed as often as may be necessary, probably in most cases every 24 hours, until the wound is granulating healthily, when skin-grafting (see Vol. I. p. 54) should be employed. Unless the surface be skin-grafted it will take a long time to heal, especially if the carbuncle be situated on the back of the neck ; in this situation the destruction of tissue may lead to inconvenient contraction if the area be left to cicatrise.

Free incision alone without scraping, such as is possible without an anæsthetic, is not nearly so good as either of the methods just described, and, while relief may be no doubt given by promoting the escape of discharge and relieving tension, the septic process is not arrested, and the healing process will be prolonged, and during it the patient will remain liable to general septic disease. If, however, the carbuncle be got rid of in one of the ways just described, and skin-grafting be employed subsequently, the duration of the case is much shortened.

Anti-staphylococcic vaccine may be used in these cases, but the evidence in favour of it is not so strong as it is in the case of furunculosis (see p. 6). A carbuncle is a very acute process, and it is doubtful whether the lowering of the patient's resisting power, which occurs at the commencement of the treatment, may not be prejudicial. The value of a vaccine in these cases still remains to be proved.

MALIGNANT PUSTULE OR ANTHRAX.

Anthrax is a disease of the lower animals, especially of sheep and cattle, but it sometimes affects man, and comes under the notice of the surgeon in the form known as malignant pustule. The disease is due to the bacillus anthracis, which grows in the dermis and subcutaneous tissues, but has a great tendency to pass into the blood-vessels and cause general infection. It occurs especially in those, such as tanners, mattress-makers, butchers, etc., who are brought in contact with the skins and hair of infected animals, and it is caused probably in all cases by direct inoculation through lesions of the skin or mucous membrane.

Inoculation is followed by a period of incubation, then by the appearance of a red spot, and subsequently of a vesicle. When the condition is fully developed, there is a central black area which is a slough, and outside this are one or more circles of small vesicles, and outside that again

an œdematous and erythematous condition of the skin. In advanced cases there is enormous swelling and brawniness of the parts, and wide extension of the œdema, which, in certain situations, as in the neighbourhood of the upper air passages, may in itself be a very serious danger. This is accompanied by enlargement of the nearest lymphatic glands, and, if the case be left to itself, it usually goes on to extension of the gangrene, phlebitis, lymphangitis, internal complications, and death. As regards the general symptoms, there is from the first a small feeble pulse, a dry skin, a temperature up to 104° F., and subsequently bloody urine, the patient passing into a typhoid condition in which death occurs.

TREATMENT.—**Prophylactic.**—In the first place, if there be any suspicion that the animal or the hair is contaminated with the anthrax bacillus, precautions must be taken at once to disinfect any accidental cut or scratch that may occur in those that work in contact with it. Any wound should be thoroughly cauterised, first of all with a red-hot iron, and then with undiluted carbolic acid. The skin around should be disinfected with the strong mixture (see Vol. I. p. 50), and antiseptic dressings applied.

Local.—In the **milder cases** the best treatment is to *excise* the pustule completely whenever its size and situation render this safe, and then to use *the actual cautery* to the wound left, and afterwards to apply *undiluted carbolic acid* to the cauterised area. The application of *chloride of zinc* paste[1] to the raw surface left by the excision is often practised. It is, however, not so reliable as the application of the actual cautery, and gives rise to more pain afterwards. The progress of the affection is so rapid that, unless the whole of the disease be destroyed at the first sitting, there is not much chance of the somewhat tardy action of the chloride of zinc overtaking it. Before excision, the pustule and the portion of skin to be removed should be sponged with undiluted carbolic acid, the skin around strictly disinfected, and all concerned in the operation should wear rubber gloves. The mass to be excised should be handled only with *vulsella* forceps and no discharge should be allowed to contaminate the wound. All swabs or sponges used in the operation should be burnt, owing to the resistance of the spores of the bacillus anthracis to antiseptics. The wound should be stuffed with cyanide gauze.

In more advanced cases the brawny swelling should be *laid freely open*, the slough cut away, and the raw surface thoroughly destroyed with the *actual cautery*, and subsequently soaked with *undiluted carbolic acid*. In addition to these measures, some surgeons recommend injections of carbolic acid into the tissues around the pustule when there is much œdema. For this purpose a 1 per cent. watery solution is employed and two or three drops are injected hypodermically at numerous points in a circle

[1] Zinc chloride 1 part, extract of opium $\frac{1}{20}$th part, and flour 4 parts. Mix with water into a stiff paste and apply for 24–48 hours. Then apply fomentations until the sloughs separate.

all around the area of redness. If the treatment prove successful, a granulating wound is left, which must be skin-grafted.

Recently Sclavo has introduced a *serum* from which remarkable results are said to have been obtained either alone or in combination with the methods described above. We have had no personal experience of this, but the reader may consult Dr. T. M. Legge's excellent Milroy Lectures on 'Industrial Anthrax' (*Lancet*, March 18, 1905 *et seq.*). If the serum be obtainable it should certainly be used, at any rate in the more advanced cases which are the ones having a high mortality. The serum may be obtained from some of the leading chemists, or from the Lister Institute.

General.—As much nourishing and easily digested food as possible must be given. Stimulants—sometimes in large quantities—will be called for, and quinine in 5 to 10-grain doses every four hours, or Warburg's tincture in drachm doses at similar intervals is also useful. Powdered de-emetinised ipecacuanha, in doses of 40–60 grains given every four hours as long as the patient can retain it, has been highly recommended. We have no personal knowledge of its use, but in any case it should only be tried as an adjunct to vigorous operative treatment.

TUBERCULOSIS.

This affection occurs in four forms: (1) Tuberculous ulceration; (2) Tuberculous warts; (3) Lupus; and (4) Tuberculous nodules in the subcutaneous tissue, termed *gommes scrofuleuses* by the French.

TUBERCULOUS ULCERATION.

Tuberculous ulcers occur on the skin or mucous membranes either primarily, as the result of direct inoculation from the outside, or secondarily from infection from beneath, as after rupture of tuberculous abscesses. In phthisis, tuberculous ulcers are comparatively common on various mucous membranes, especially in the intestine, the tongue, and the throat; they are probably due to direct inoculation of the part by the bacilli contained in the tuberculous sputum. Elsewhere, the ulceration generally results from the bursting of deeper-seated abscesses, but it may also be due to external inoculation. The tuberculous ulcers are often multiple, and form sores of various sizes with sharply cut and undermined edges. The base is usually not indurated, the granulations are greyish and imperfect, and a sort of sero-pus, which has a great tendency to form crusts, is secreted from the surface. As a rule the ulcers are not painful, except when they are situated on the lip, or about the anus, etc., when they may cause intense pain.

TREATMENT.—**Excision.**—Tuberculous ulcerations, of course, require local treatment; if possible, the best is to excise the sore as soon as its tuberculous nature is determined; it should be done with full

antiseptic precautions. When the wound left is small, it will be found feasible to bring the edges together by a little undermining of the skin in the vicinity; if this be impossible, skin-grafting may be employed. Excision is the best of all methods of treatment for local tuberculosis.

Scraping and Cauterisation.—When excision is not feasible, scraping and thorough cauterisation of the raw surface with nitric acid (see Vol. I. p. 80) is indicated. Excision is seldom practicable in tuberculous ulcerations of mucous membranes, and here it will be necessary to be

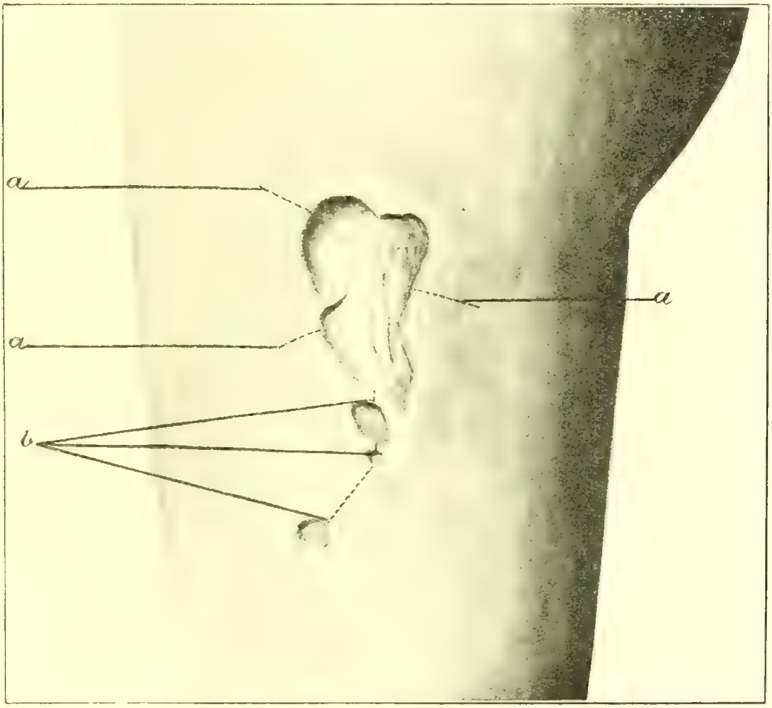


FIG. 4.—TUBERCULOUS ULCER. *a a a*, Lines of incision for dividing the undermined edges; *b b b*, bridges of tissue which are to be divided along the incision marked by the broken lines.

content either with scraping the ulcer, with the application of various substances to its surface, or with a combination of the two methods. Perhaps the most useful application is a 1 per cent. solution of *chromic acid* in water, brushed over the part daily or every other day, or at less frequent intervals later if there be delay in the healing. A single application of pure chromic acid melted on a probe may also be used. *Pure lactic acid* is also much used in ulceration about the throat and larynx. For relief of pain, dusting with *orthoform* powder daily is the best treatment.

Division of Undermined Edges.—When the skin or mucous membrane is undermined, and the patient will not agree either to excision or scraping,

the thin undermined edges must be divided; they are stretched and thin, and will never develop into healthy tissue. They need not necessarily be cut away, but several incisions should be made through them radiating from the centre of the ulcer well into the healthy skin beyond. As a result of this, the skin between the incisions contracts and a number of tags are left which will readily adhere and form new centres for epithelial growth. As a rule, however, if a presentable scar be desired, it is better to clip away all these tags at their junction with the sound skin. This can be done under cocaine or after freezing.

The treatment of tuberculous ulcers of the skin, secondary to tuberculous abscesses, depends, of course, on the treatment of these abscesses, and will be referred to in speaking of tuberculous sinuses in connection with joints, etc.

TUBERCULOUS WARTS.

Tuberculous warts—which are also known as lupus anatomicus—are mentioned in Vol. I. p. 172. They occur in *post mortem* porters, or those who do much *post mortem* work. They form irregular papillomatous elevations, and fissures are very often found between the bases of the papillæ. As a rule they are indolent, the surrounding skin is normal, they are benign and slow in their course, and the glands do not usually enlarge. In some cases of lupus anatomicus, however, the course of events may be much more acute, and there may be enlargement of the glands, disease of subjacent joints, or even phthisis.

TREATMENT.—This is practically the same as that of lupus; when the disease is not too extensive, the best plan is completely to excise the group of warts.

TUBERCULOUS LUPUS.

Lupus may be met with in any part of the body, but it is most frequent about the cheek, the nose, and the back of the hands. The disease is characterised by the presence of nodules which, under the microscope, are found to consist of a collection of tubercles. These nodules tend to spread at the margin of the patch, while healing often occurs at its centre. In some cases the epidermis remains unbroken, and the nodules present a yellowish translucent apple-jelly-like appearance, or the epidermis is slightly thickened and scaly, the nodules are dull, and there is a slight congestion of the skin around. In this form of the affection the tubercles tend to dwindle after a time, leaving a soft violet-coloured cicatrix; in other cases there is ulceration.

The ulceration tends to heal, and when it does so, the scar often causes considerable contraction and deformity; in the cheek, for example, it pulls on the lower eyelid, causing eversion or ectropion. This form of lupus is especially destructive; when it occurs on the nose it spreads from the skin to the cartilage and destroys it, then it extends to the mucous mem-

brane, and may thus completely destroy the soft parts of the nose, leaving the bones intact, however. The course of the disease is exceedingly slow, as a rule, and years may elapse before any marked destruction is caused.

TREATMENT.—The disease is a local one, although it often occurs in patients who have an hereditary tuberculous taint, or who are suffering from tuberculosis elsewhere. Hence, although **general treatment**, such as is recommended in Vol. I. Chap. XII., is advisable in all cases, the disease will not, as a rule, disappear without local interference.

The methods of **local treatment** have undergone great changes in recent years, and we are indebted to our colleague, Dr. Arthur Whitfield, Physician in charge of the Skin Department at King's College Hospital, for the following account of present-day knowledge :—

'The treatment of lupus may be considered under four headings :—
'(1) By surgical operation.
'(2) By physical means without operation.
'(3) By drugs and caustics.
'(4) By attempts to immunise the patient to the specific bacillus.

'(1) **Operative.**—Small patches of lupus may be excised and the edges brought together, so that a neat linear scar results. In the present state of knowledge this is probably always the best method where possible, as relapse is extremely rare and the scar is practically negligible The points to remember are that the incision should go sufficiently wide of the disease, at least a quarter of an inch, and, above all, so deep that the knife does not cut through any infected tissue with the consequent risk of contaminating the wound. Larger patches may be excised, and the raw surface left may be skin-grafted. This method of treatment is not to be recommended unless there are urgent reasons for it, since the result, where successful, is the production of a bad scar, and, moreover, relapse occurs within the grafts in the great majority of cases.

'Scraping with the Volkmann's spoon is still used a good deal, but it should never be trusted to alone. An efficient scraping, first with a good sized and afterwards with a very small spoon, followed by the packing of the raw surface with a paste made up of powdered zinc chloride and glycerine, gives wonderful results in many cases. It is true a few nodules often recur, but if these are persistently bored out and filled up with zinc chloride paste the disease in many cases may be actually cured and the resulting scar, though often a good deal thickened, is usually less unsightly than that after Thiersch grafting. Scarification, which has gone a good deal out of fashion, still has its advocates. With a single Vidal's or a multiple knife, the whole area is minced up very finely by cross strokes, and after the bleeding has stopped sterilised iodoform is rubbed in vigorously. The process is not very painful, but it has to be repeated several times. The resulting scar is hardly visible.

'(2) **Non-operative.**—A. *The Light Method.*—After a great deal of

discussion it now seems to be established that the best effects are produced by a concentrated white light and not by any attempt at the use of the ultra-violet light, since this latter is not capable of penetrating deeply enough. The two lamps which appear to be generally useful are the original, high voltage Finsen lamp, capable of treating four patients at once, and the newer Finsen-Reyn focussing lamp, which treats single patients. The latter needs special wiring, but can then be run from the ordinary constant house current, while the former entails a very costly installation. The important points in securing success are, first, the efficient pressure with the quartz compressor, so that every part of the treated area is kept evenly anæmic (injection of adrenalin has also been used for this purpose) ; secondly, the continued application of the light after the apparent disappearance of the disease. Nine to twenty-five exposures are usually sufficient for a single area, but where there is thick scarring or the patient is very dark complexioned, a much greater number may be required, and only an area the size of a shilling piece can be treated at one exposure, which lasts from twenty minutes to an hour. The resulting scar is perfect, no destruction being caused, so that only the loss of tissue, already produced by the disease, remains. Unfortunately relapse is frequent.

'B. *By X-rays.*—This method is particularly successful in those cases where ulceration is a marked feature, and which are therefore unsuitable for the light treatment at first, since one can hardly compress an ulcerated area. Under the use of the X-rays scars soften down, ulcers heal, and, in rare instances, actual nodules disappear. The method is, however, unreliable owing to the want of uniformity in the results. Moreover, there appears to be a distinct risk of inducing the growth of malignant disease in the exposed area. If used, the X-rays should be given in "pastille" doses, one such dose being given every four weeks.

'C. *By Hot Air.*—Hollander has recommended slight cauterisation by pumping air through a glowing porcelain mass on to the part. The destruction is not carried far enough to leave a scar, and the method, therefore, probably acts by bringing fresh blood to the parts. The pain produced is severe, but he has claimed excellent results which have not been very frequently corroborated.

'(3) **By Drugs and Caustics.**—These may be regarded either as palliative or curative, and the former are largely resorted to as preliminary to treatment by other means. Brooke's ointment is that which is, perhaps, the most efficient of the palliative applications, and under it all septic complications rapidly subside, ulcers often heal, and, in some instances, a few nodules may disappear. It has the following formula :—

℞ Acid salicyl.	gr. xx.
Pulv. zinci oxidi } Pulv. amyli }	āā ʒij.
Ichthyol	♏ xx.
Paraffini mollis	℥ ss.
Ung. hydrarg. oleat. (5%)	℥ j.

Others use sulphur in ulcerated cases, and others again simple mercurial applications such as lotio flava or lotio nigra.

'The drugs which are commonly used for the destruction of diseased areas, and the actual cure of the disease, are :—Salicylic acid, pyrogallol, chloride of antimony, carbolic acid liquefied, permanganate of potash. The usual method employed with all of these is first to apply the drug in plaster or a paste spread on lint over the whole surface, and, when most of the disease is eradicated, to bore out individual nodules with a piece of pointed wood such as a burnt match. Unna advocates the use of thorns soaked in antimony solution, and claims that these give the best results. They are thrust into the bottom of the nodule, cut off flush with the surface and allowed to exfoliate.

'Salicylic acid, when used, is generally made up in a plaster with some creosote to obviate the pain that would be caused otherwise, but these plasters are, as a matter of fact, very painful.

'Pyrogallol may be used in the following formula, which is absolutely painless in use :—

℞ Acid pyrogallic	ʒj.
Anaesthesin	gr. xl.
Pulv. zinci oxidi } Pulv. amyli }	āā ʒj.
Paraffini mollis	ad ℥j.

(over small areas only).

After complete necrosis of every nodule appears to have occurred, the raw surface should be allowed to heal under a weaker (2–3 per cent.) paste.

'Chloride of antimony is seldom used in this country, its great disadvantage being the tendency to produce hypertrophic scarring. Pointed pieces of wood may be dipped in a strong solution of the trichloride, or an ointment containing 10 per cent. of the solution may be applied.

'Carbolic acid may be painted on, and introduced by boring. It is painless and not very efficient as a destructive agent, but it is valuable painted on, as recommended by Jacob of Nottingham to increase the transparency of the tissues before light treatment.

'Permanganate of potash is used in France, but the results seem to be much the same as with the other caustics. Unquestionably pyrogallol is the best.

'**By Immunisation.**—Two main principles of treatment may be mentioned under this heading, namely, that in which the dosage is controlled by means of the opsonic index, and where in consequence the dose remains small; and that in which the dosage is guided by the clinical reactions of the patient, and in which it is the aim to raise the doses to high amounts.

'In using the opsonic method it is usual to start with a dose of new tuberculin containing from one ten-thousandth to one two-thousandth of solid substance, and this is not necessarily increased during any part

of the treatment. After a fairly abundant experience of my own cases treated by this method, and also of those of other investigators treated for long periods, I am in a position to state that I have seen no case in which a really curative action was manifest, that is, in which the disappearance of numerous nodules has been observed.

'The second method may be carried out by means of either the original or the new tuberculin, and of these I have no hesitation in giving preference to the original tuberculin. In view of the generally expressed view that the treatment with old tuberculin is not free from risk, it is best to carry out a careful examination of the important viscera, in order to be certain that there is no gross lesion in any of these organs, which might be a contra-indication to the treatment.

'I usually begin with one four-thousandth of a cubic centimeter of the fluid, and find that this does not usually cause any constitutional reaction. The dose is doubled on the second occasion if no reaction takes place and is doubled again on subsequent occasions until a fairly sharp reaction is caused. The same dose is then maintained until it is borne without any severe reaction, when it is again increased, but as one gets to larger amounts, *i.e.* over one five-hundredth of a cubic centimeter, it is wiser not to double the dose, but to increase it more gradually, being guided by the reaction as to the suddenness of the increase. In no case have I given more than one-fifth of a cubic centimeter of the original fluid.

'I do not claim that every case of lupus is suitable for this method, but I regard it as an extremely useful one for those cases in which excision is out of the question, and the Finsen light is not applicable or not to be obtained.'

SCROFULOUS GUMMATA.

The fourth form of tuberculosis of the skin and subcutaneous tissue is that spoken of by the French as 'gommes scrofuleuses' or *scrofulous gummata.* Here nodules form in the skin or subcutaneous tissue, which are at first hard, but which in time soften and break down, and lead to the formation of abscesses. In this way multiple chronic abscesses are found often widely distributed over the body, which burst and give rise to tuberculous ulcerations of the skin with sinuses extending into the deeper tissues. This condition occurs chiefly in infants, in whom the nodules are subcutaneous; in adults it is rarer, and the nodules are in the skin. On examination, the nodules are found to be tuberculous tumours.

TREATMENT.—The nodules should be excised without cutting into them; if fresh ones form they should be excised also. These nodules are very chronic in their course as a rule, and incision and scraping are not nearly so rapid or certain in their results as excision. The immunisation method described (*vide supra*) is worth a trial in these cases, should

excision be refused or be inadvisable. Thyroid extract in doses of 3-5 grs. may be given three times a day to adults and in proportionate doses to children.

TUMOURS OF THE SKIN.

These may be innocent or malignant, primary or secondary.

INNOCENT TUMOURS.

SEBACEOUS CYSTS.—These common tumours of the skin consist of a cavity lined with squamous epithelium, and containing epidermic scales, sebaceous matter, and cholesterin. They are due to a blocking of the orifice of the sebaceous duct and dilatation of the gland behind; it is usual to find a small pit, which is the blocked orifice of the duct, in the skin over the centre of the cyst. Sebaceous cysts are situated in the skin itself, and are thereby distinguished from dermoid cysts which occur in the subcutaneous tissue. The tumours are at first flattened, and then become spherical; they generally occur in hairy parts, such as the scalp. The cyst always possesses a well-defined wall.

Treatment.—In parts where the skin is thick the cyst wall is tough, so that it is easily shelled out from the loose connective tissue by which it is surrounded. On the face, however, the cyst wall is thin and delicate, and there is little or no loose cellular tissue around it, so that careful dissection is required for its complete removal. Unless the entire cyst wall be removed, recurrence is certain. Where there has been much friction, the result of the inflammatory exudation may be that the cyst wall becomes adherent in places and is difficult to remove.

Of Cysts on the Scalp.—The hair should be shaved along the proposed line of incision, the skin and hair around rubbed over with ether soap or acetone, thoroughly washed with strong mixture, and the hair converted into an antiseptic mass by rubbing into it double cyanide of mercury and zinc powder made into a paste with a 1 in 20 carbolic acid solution; this is rubbed in until the hair in the vicinity is thoroughly impregnated with it. A narrow-bladed knife with its cutting edge turned upwards is then made to transfix the cyst and the surgeon cuts outwards, dividing everything and bringing the knife right out through the upper half of the cyst (see Fig. 5). The divided wall of the cyst can readily be seen on separating the edges of the skin, and by pulling gently upon it, it is easy to enucleate the whole cyst except when inflammation has occurred and the cyst is adherent to the skin; if this be the case, it is necessary to remove the adherent portion of the skin as well. Inflammation is not uncommon in sebaceous cysts of the scalp, owing to the friction of the hat or to infection through the hair follicles.

After the wound has been stitched up, a pad of dressing is made to press the superficial and deeper parts together, and a mass of wool and a firm bandage are put on over them. These should be removed in

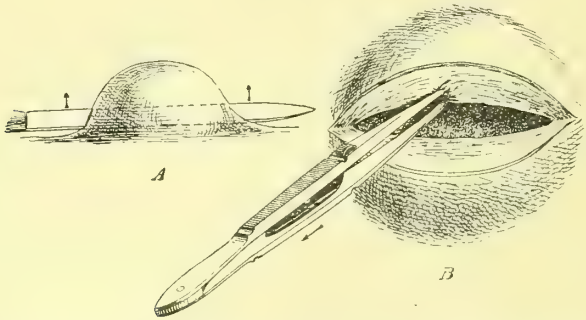


FIG. 5.—METHOD OF REMOVING SEBACEOUS CYSTS. This is the method most suited to the cases in which the cyst wall is thick and firm, *e.g.* on the scalp. The cyst is first cut across by transfixion, and its contents squeezed out; then, as shown in *B*, the wall is laid hold of by catch-forceps and traction exerted. The wall pulls out and only a mere touch of the knife is required.

about three days, the stitches taken out, and the surface of the wound and the hair around covered with fresh cyanide paste. The hair can now be combed over the wound, no other dressing being necessary.

Of Cysts on the Face.—When the skin and the cyst wall are thin, it is better to dissect down upon the tumour from without inwards and enclose in the incision an oval piece of skin corresponding to the thinnest part. Unless this be done, too much skin will be left, and a portion may lose its vitality. Besides this, it is very difficult to dissect the skin from the top of the sebaceous cyst, and the cyst wall will tear if an attempt be made to pull it out. After making this oval incision, it is generally easy to shell the tumour out of its bed by means of a blunt dissector. The skin should be brought together by fine horsehair, care being taken not to allow the thin edges to become inverted.

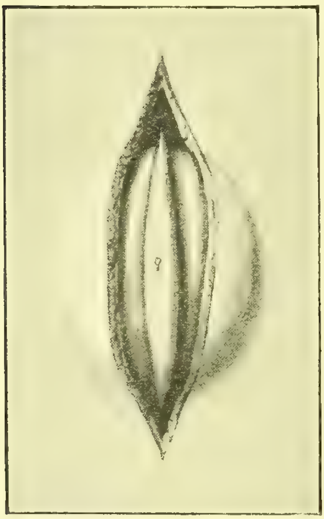


FIG. 6.—REMOVAL OF A SEBACEOUS CYST ON THE FACE. The cyst is dissected down upon from outside, a portion of the thinned skin being included in the elliptical incision.

DERMOID CYSTS.—These are referred to in Vol. I. p. 265. They are frequently met with in the subcutaneous tissues about the angles of the orbits or in the neck, in connection with imperfectly obliterated branchial clefts, most frequently, the second. The

cyst is then situated below the angle of the jaw and in front of, or partly deep to, the sterno-mastoid muscle. The lining wall of the cyst closely resembles normal skin in structure, and is furnished with sebaceous glands, and often with distinct follicles bearing hairs. The cyst generally contains a thick pultaceous material in which may be found hair, and it is not adherent to the skin unless it has been subjected to irritation; it may extend deeply between muscles and other structures.

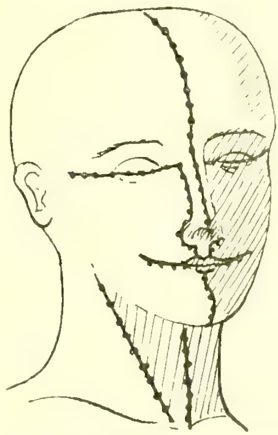


FIG. 7.—LINES ALONG WHICH DERMOIDS OCCUR.

Treatment.—Complete *excision* is the only successful method; unless the entire wall be removed, the cyst will re-form, or a persistent sinus will result. When the cyst is adherent to the skin, a portion of this must also be excised. Dermoids are usually separated easily from the surrounding structures, but when they run deeply amongst muscles, the dissection required for their removal is often tedious and difficult; this point is referred to in connection with cysts of the neck.

FIBROMATA.—These tumours may occur in the skin either as dense, hard fibromata, or, more commonly, as soft pedunculated tumours which may be solitary, but which are usually multiple and are known as molluscum fibrosum.

Molluscum Fibrosum.—In this condition soft pedunculated pendulous tumours form small tags or large masses. Sometimes the whole body is more or less covered with these growths; sometimes only a few large pendulous masses are present. They are not dangerous to life, but they are often unsightly; they may become abraded and be the starting-point of some septic trouble, and give rise to a great deal of pain.

Treatment.—Solitary pendulous masses may be snipped off, and a collodion dressing put over the small wound left. When the tumours are very numerous, it is obviously inadvisable to remove them all; only those causing definite inconvenience should be snipped off.

When large pendulous masses are present, a wedge-shaped portion may be cut out, or even the whole mass may be excised, according to its size and situation, and the edges of the skin brought together. The hard fibromata are dissected out through an incision parallel to the long axis of the tumour.

Painful Subcutaneous Tumour.—This is a form of fibrous tumour involving a nerve trunk or one of its branches. It is generally small, intensely tender, and sometimes, apart from pressure, gives rise to neuralgic pain, which radiates from the point where the

tumour is situated towards the periphery of the limb, and may be accompanied by muscular spasm.

Treatment.—The treatment is to extirpate the tumour ; but usually these patients become highly neurotic, and, in addition, it is necessary to employ treatment suitable for hysteria.

Various other tumours of the skin such as **angiomata, lymphangiomata,** are referred to in Vol. I. pp. 255, 264.

MOLES.—A mole is a soft tumour of the skin, with or without hypertrophy of the hair follicles and the pigmentary layer ; it may or may not be pigmented.

Treatment.—The danger of pigmented moles is that they may become the starting-point of melanotic sarcoma as the patient gets older, and, therefore, if there are only one or two isolated pigmented moles present it is best to excise them, whether they are causing disfigurement or not. Sometimes a mole may give rise to wide-spread metastatic deposits without itself showing any changes at all. Hairy pigmented moles on the face are very unsightly, and should be cleanly and completely excised whenever possible ; even in the most extensive cases, excision followed by immediate skin-grafting will give an improved appearance. When grafting in these cases, it is important to try to cut one single graft broad enough to cover the raw surface completely, as otherwise the lines of junction of the individual grafts may be a source of subsequent disfigurement.

When there is a very large hairy mole, whose size forbids excision, for instance, on the forehead, the hair can be removed by means of electrolysis ; the pigmentation remains.

MALIGNANT TUMOURS.

These may occur under three forms, namely, Sarcoma, Rodent Ulcer, and Epithelioma.

SARCOMATA of the skin, with the exception of the melanotic form, are not common, and when met with must be treated by complete excision, followed by the removal of recurrent nodules should they occur (see Vol. I. p. 246).

RODENT ULCER begins insidiously. There is often a history of slight traumatism followed by a sore place, which becomes covered by a scab, under which the growth slowly spreads. When the scab is detached, a good deal of hæmorrhage may occur. The ulcer has a reddish base devoid of granulations, is indolent, and has very little thickening, either about the base or the edges. Sometimes the latter are sharply cut, and occasionally the epithelium makes an attempt to spread over the surface of the ulcer. The condition is a true carcinoma, the cells, however, not being squamous epithelium but smaller elongated cells, and the tumour tends to break down and ulcerate almost as fast as it grows. The

disease goes on steadily if left to itself, and gradually destroys all the tissues that it encounters in its spread ; its rate of growth is exceedingly slow. It may occur on any part of the body, but is most commonly met with on the side of the nose, just below the orbit, at the outer angle of the eyelids, and in the parotid region. The glands do not become affected.

Treatment.—Excision, which was at one time the method of choice, has given way to treatment by radium, though very small rodent ulcers may be dealt with satisfactorily in this way.

For the following account of the newer methods of treatment we are indebted to Mr. A. D. Reid, Radiographer to King's College Hospital :—

'**Treatment of Rodent Ulcer by Radium or X-Rays.**—The best method of treatment for rodent ulcer consists in the application of one of the salts of *radium*, and the bromide is usually employed. The radium bromide should be enclosed in a capsule preferably with one side flat. This side consists of platinum $\frac{1}{2}$ millimeter thick. The platinum filters out the α-rays, and allows the β- and γ-rays to pass through.

'The length of time of application depends on the quality and quantity of the radium employed.

'If the radium only covers ulcerated tissue, an exposure of three or four times longer can be given than would be safe on unbroken skin. For small ulcers which are not deep, small quantities (10 mg.) are enough, but it is better to employ 50–100 mg. with the latter amount. A simple exposure of from one to four hours will be sufficient to effect healing.

'Where radium is not available, the next best method is to employ the *X-Rays* with which most satisfactory results have been obtained.

'The apparatus usually employed to excite the tube consists of a 10–12 inch coil worked off the continuous main or from accumulators with a mechanical interruptor such as the Mackenzie Davidson break. The tube is enclosed in an opaque shield made of rubber or lead glass with a central aperture, to which can be fitted diaphragms of different dimensions. A milliampèremeter is inserted in series with the tube. A diaphragm should be selected of such a size that it can include the whole of the area to be treated with about half an inch of healthy skin around.

'Operators vary in their opinions as to the exact details of technique, but the following has been abundantly tested and will be found to give excellent results.

'A tube with a 3–4 inch alternative spark gap is employed, with a current of half a milliampère. The anode of the tube is placed six inches from the affected part and exposures of five minutes—raised after six sittings to ten—are given three or four times a week until eighteen applications have been given, when the treatment is stopped for a fortnight. In most cases considerable improvement will be noticed by this time.

'After three weeks, by which time it is usually possible to estimate the amount of reaction which has been produced, a second course may be

commenced. The reaction is assisted by the application of a strong irritating antiseptic dressing such as 1 in 20 carbolic acid. This plan of treatment is pursued until a healthy, flat, granulating surface is obtained.

'This means that all the growth has been removed and all that is needed to complete the healing is the application of a mild antiseptic dressing, such as boric acid ointment.

'Another method of applying the rays is to give maximal doses at intervals, the maximal dose being measured by means of "a pastille" which changes colour to a standard tint when the largest amount of the X-rays has been applied that can be used without giving rise to erythema. The dose is repeated at intervals of three weeks.

'When the disease has attacked bone or cartilage, a preliminary operation will be necessary to remove the necrosed portions. When this has been done, X-ray treatment may be commenced with some hope of success. Unless this removal of necrosed portions has been undertaken, it has been found that, even after prolonged exposure to the rays, healing does not take place.

'Although it is easy to obtain a scar which is apparently quite sound and free from disease, yet recrudescence is the rule. Fortunately these recrudescences are as amenable to treatment as the original growth. It is advisable therefore that patients should be kept under observation for a prolonged period after healing has taken place.'

EPITHELIOMA.—Two forms of this affection are met with in the skin, namely, the flat superficial form and the tuberous variety. The flat epithelioma is a superficial hardness of the skin, a kind of parchment induration usually beginning in a sebaceous nodule or a mole, and generally occurring in old people. It is not particularly malignant, and may exist for a considerable time before enlargement of the glands takes place.

Treatment.—The disease can generally be arrested by excising the indurated area. Excision should be practised without hesitation on any enlarging nodule about the face in old people, especially an old sebaceous patch or a mole that has existed for many years and has recently begun to increase in size. The microscope will generally show that the nodule is an epithelioma limited to the surface of the skin. Radium, as now used, may be of value in these cases, particularly when, owing to the situation of the growth, free excision in every direction is not feasible.

The tuberous epitheliomata are much more malignant, and give rise to comparatively early infection of the glands. The extent of the operation required for their excision will depend on the situation of the growth; a description of the operations will therefore be found in connection with the affections of the regions in which they occur. The glands, if enlarged, should also be excised. A question of great importance is whether the lymphatic glands should be removed, if they are not enlarged, at the time of removal of the growth. When the growth is in such a situation that

it is possible to tell which glands will be first infiltrated, it is undoubtedly advisable to remove these glands, although they are not obviously enlarged. When, however, this is doubtful, it is justifiable to excise the primary growth and leave the glands till they become enlarged. In such cases the patient must be kept under close observation and examined every three or four weeks, in order that the removal of the glands may be done whilst the disease is still limited to them. One other point is also of importance, namely, whether it is necessary to excise the lymphatic vessels and fat, lying between the primary tumour and the glands, as is so strongly to be recommended in breast cancer. It seems, however, that in most cases of the kind which we are now considering it is not necessary. The lymphatic vessels seldom become infected in their course from the primary tumour to the glands. Why this should be so is not very clear, but it is a clinical fact.

CHELOID.

The cheloid condition of scars is fully dealt with in Vol I. Chap. X. p. 204, but we may here refer to the **true or Alibert's cheloid,** which is supposed to arise spontaneously. These tumours are chiefly situated in front of the sternum and begin as small tubercles which slowly increase in size, sometimes by the coalescence of neighbouring nodules, until they form a firm tumour with an unequal surface, an irregular shape, and edges of a rosy or violet colour running out in the form of ridges.

TREATMENT.—This must be on lines similar to that for false cheloid (see Vol. I. p. 205). Excision is unsatisfactory, as the scar tends to become cheloid again ; it is possible, however, to convert by excision, a large broad tumour into a linear one in this way, and Goldmann has stated that there is no recurrence of the cheloid if the growth be excised freely and the raw surface left be covered immediately with Thiersch's *skin-grafts* ; this, however, is not always the case. Radium has proved useful in some of these cases.

CHAPTER II.

AFFECTIONS OF THE NAILS.

HYPERTROPHY.

In this fairly common affection the nail becomes thickened and marked by transverse depressions, while its tip becomes unduly curved. In old people the nail of the great toe and sometimes, to a lesser extent, those of the others may assume the shape of a horn, the point of which turns over towards the sole or curves round and threatens to grow into the nail matrix or the free end of the toe. This affection often results from inflammation or injury, and is called **onychia gryphosa.**

TREATMENT.—When a nail that is the subject of onychia gryphosa assumes the shape of a horn, it must be carefully pared, as otherwise its tip will grow into the matrix and cause ulceration. When the horn is very massive and dense, the entire nail and its matrix may require removal.

INJURIES.

CONTUSIONS.—Contusions of the nails are often followed by separation of the nail from its bed. The usual effect of the contusion is to cause hæmorrhage between the nail and the matrix; when the latter has been badly contused, and blood is seen as a black mass beneath the nail, separation of the latter can sometimes be prevented by making a hole through it over the hæmorrhage so as to allow the blood to escape. This is easily done by scraping with a piece of glass or the edge of a knife until the nail is thin enough to permit of the introduction of one blade of a pair of sharp-pointed scissors. The operation is quite painless; a small antiseptic dressing should be applied to prevent the occurrence of suppuration beneath the nail.

FOREIGN BODIES lodged beneath the nail should be removed at once, because they not only cause much pain at the time, but are apt to lead to suppuration, and possibly irregular destruction of the matrix and consequent deformity of the nail. After extraction of the foreign body it is a good plan to snip away the portion of the nail beneath which it lay with sharp-pointed scissors, and then to apply a boric fomentation for twenty-four hours. Unless this be done, there is considerable danger of septic trouble, as there is little chance of the septic products escaping freely should the wound suppurate.


A *B*

Fig. 8.—Removal of a Foreign Body from beneath the Nail. In *A* the foreign body is seen extending beneath the free margin of the nail. In *B* the nail is shown cut away to expose the splinter and allow of its being withdrawn.

INFLAMMATORY AFFECTIONS.

The most important affections of the nails are those which are grouped together under the name onychia. This term is applied to inflammations of the soft parts around the nail or of the matrix beneath it ; there are several forms of onychia.

ACUTE TRAUMATIC ONYCHIA.

This is the ordinary inflammatory condition, under or at the side of a nail, which is usually caused by the presence of a foreign body, as, for example, a splinter of wood. This is followed by suppuration, and small collections of pus form under the nail and open in front or at the side of it, and the result may be that the nail is lost.

TREATMENT.—The foreign body must be removed at once if it can be recognised, but if not, the pus should be evacuated by gently detaching the nail from the matrix until the abscess is reached, and then clipping away the detached portion. This can sometimes be done by freezing, but when the affection is too painful for this, a general anæsthetic, such as nitrous oxide, should be employed. When the small drop of pus has been evacuated, and the nail over it cut away, the inflammation quickly ceases under the application of wet boric dressings (see Vol. I. p. 51). The affected portion of the matrix will recover, and the nail will grow well afterwards.

INGROWING TOE-NAIL.

A second form of onychia which gives rise to a great deal of trouble is that known as lateral onychia, or as it is commonly called, from the fact that it exclusively affects the toe, 'ingrowing toe-nail.' In this condition there is inflammation of the matrix and skin at the side of the nail, generally on the outer side of the great toe. It usually occurs

in young male adults of the working class, who have much walking to do, who do not keep the feet clean, who wear badly fitting boots, and cut the great toe nail so short that it does not project beyond the soft parts. The result is that the nail is pressed down and irritates the lateral fissure or, what comes to the same thing, the soft parts of the toe are pressed up against the nail; hence, as a rule, the affection occurs near the free end of the nail. It begins with slight pain and swelling, which impede walking. Ulceration soon occurs and spreads backwards along the lateral groove. In bad cases the suppuration is abundant and fœtid; there is a good deal of swelling, and the granulations are exuberant. The condition is often serious on account of the pain and lameness it induces, and also on account of the risk of lymphangitis.

TREATMENT.—This will vary according to the stage of the disease, but in all cases what may be termed the *hygiene of the foot* should be carefully attended to. The nails should be cut square, and their edges should project slightly beyond the soft parts ; the feet should be kept clean, the socks changed frequently, and the patient should wear well-fitting shoes or boots. If the case be seen before any ulceration has occurred, it sometimes suffices to introduce a minute pad of boric lint between the nail and the lateral fold so as to take off the pressure of the edge of the nail, the other points in the hygiene of the foot being carefully attended to. This procedure is most likely to succeed when the nail is thick and well-developed ; when it is thin and papery it is of little use. If ulceration has taken place, however, this plan will not suffice.

In the later stages, various other methods are resorted to, but all, with one exception, are more or less ineffectual. Some surgeons content themselves with *cauterising* the prominent granulations, either by the application of nitrate of silver or by dusting them over with crystals of nitrate of lead, and interposing a pad of dressing or a piece of tin-foil beneath the edge of the nail ; others clip away the portion of the nail which is pressing on the skin—an exceedingly bad plan, as it really aggravates the trouble in the end—and others again *remove half or the whole of the nail.* If it be desired to remove the whole or one half of the nail, the patient is put under an anæsthetic—gas is generally sufficient—and then if one *half* of the nail is to be removed, one blade of a pair of sharp-pointed scissors is passed down in the middle line between the nail and the matrix right to the root, the nail is split down the centre, and the half on the side affected torn away by forceps. If the *whole* nail is to be removed, it is detached and torn off by forcible traction with a special pair of forceps termed 'onychia forceps,' one blade of which is thrust down between the nail and the matrix, well to the root of the nail in the middle line, and then on closing the blades, the nail is firmly grasped between the blades and wrenched from its bed, after being loosened by turning the forceps forcibly, first to one side and then to the other.

None of these methods, however, are quite satisfactory. After removal of half or the whole of the nail, recurrence of the trouble is apt to take place as the fresh nail grows, and nothing short of the destruction of the matrix on the affected side of the toe is sufficient to prevent it. In some cases this may be done effectually after removal of the nail by carefully paring away the matrix with a knife, but it is very uncertain, as portions are apt to be left behind. In order to make sure of a successful result, the following simple operation is the best: The patient being under an anæsthetic, a lateral flap (see Fig. 10) is cut at the side of the toe by entering the knife vertically at the base of the nail just outside the ulcerated area. The point of the knife as it comes against the ungual phalanx is carried around it, immediately outside the bone and in contact with it, and, finally, the point is protruded on the plantar surface of the toe at the point opposite to the one at which it was entered. A lateral flap is then made by carrying the knife straight forward and bringing it out beyond the nail (see Fig. 10, *A* and *B*). It is not always necessary to make a wound on the plantar surface. If the cut be carried well downwards in front, the flap can generally be turned aside without making any

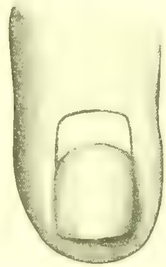


FIG. 9.—EXTIRPATION OF A NAIL. The unbroken line shows the extent to which the nail is implanted beneath the skin, and the point to which operation must be extended completely to extirpate the nail.

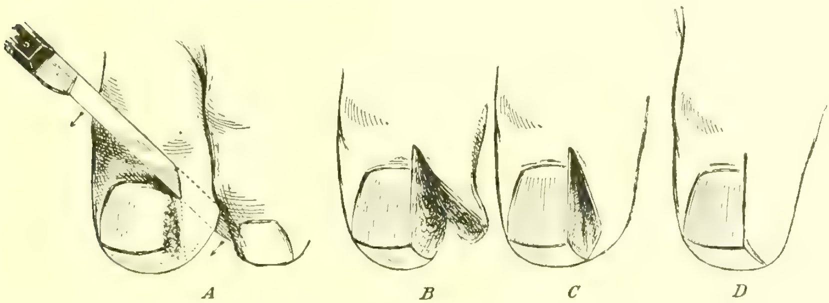


FIG. 10.—OPERATION FOR INGROWING TOE-NAIL. In *A* is shown the method of cutting the lateral flap. In *B* the flap has been cut, the portion of the nail removed and the matrix beneath cut away. In *C* is shown the second method of performing the operation without forming a flap; a deep wedge-shaped gap is produced. *D* shows the final result in both cases, when the parts are brought together.

incision on the under surface of the toe (see Fig. 10, *C*). The nail is now split with scissors from the free edge to the base, a little to the outer side of the centre, and the portion on the affected side is pulled away by forceps. The matrix beneath the portion thus removed is then dissected away. Care must be taken to remove it right back to its extreme

limit, for it must be remembered that the matrix extends backwards beneath the skin for about a quarter of an inch (see Fig. 9); any portion left behind will give rise to fresh growth. When this has been done, there is a flap at the side of the toe and a raw surface corresponding to what was previously the outer portion of the nail (see Fig. 10, *C*). The flap is made to cover this raw surface, and is fixed in position by two or three stitches.

The result of this operation is that no nail grows on the side operated upon, and, as the edge of the remaining portion of the nail is on a higher level than the skin, the soft parts cannot be pressed up against it, and no recurrence can therefore take place, even though tight boots be worn, or even though the affected toe be on the top of the one next to it. The wound usually heals by first intention, and after a fortnight no further dressings are necessary, and the patient may be allowed to walk about. The disinfection of the toe before operation must be carried out with the minuteness required for all operations in this situation; micro-organisms are very abundant in the folds about the toes and nails.

SYPHILITIC ONYCHIA.

Syphilis may affect either the nail itself, when it is called ungual onychia, or the soft parts around it, in which case it is said to be of the peri-ungual variety.

UNGUAL ONYCHIA.—The first form of syphilitic onychia chiefly affects the nails of the hands, which become friable and often partially detached. It occurs about the same time as the squamous syphilides on the skin.

Treatment.—This is mainly that for secondary syphilis (see Vol. I. Chap. XI.). The finger should be wrapped up in mercurial plaster or unguentum hydrargyri, or 5 per cent. oleate of mercury may be rubbed into and beneath the nail.

PERI-UNGUAL ONYCHIA.—The more common and troublesome form of syphilitic onychia is that in which the parts around the nail are attacked; the affection may be of two forms—dry or ulcerating. The *dry form* is really a papular or papulo-squamous syphilide occurring at the fold of the nail. The inflammation is, however, pretty severe, and at first sight it may be thought to be of a suppurative character; no suppuration or ulceration takes place, however. This condition is treated similarly to the last.

At a somewhat later period of secondary syphilis *ulceration* is met with, and this is chiefly due to the presence of condylomata about the base of the nail, and is most frequent on the toes. The result is that a fungating ulceration, with an abundant fœtid sero-purulent secretion, occurs about the nail, and may surround the latter entirely, or may affect one side only; in the former case the nail falls off, and the condition

is more tractable. In some cases it extends deeply, and may lead to disease of the bone.

The *treatment* of this form of syphilitic onychia is that of secondary syphilis. The application of mercurial ointment, 5 per cent. oleate of mercury, or a dusting powder of calomel and starch (1 to 3) to the part, are of considerable use, and, in addition, it is advisable to remove the whole nail; it is rare for the disease to be cured until this has been done. The unhealthy ulcerated surface should then be cauterised with nitrate of silver or acid nitrate of mercury, and the mercurial preparations above mentioned applied to it. As a rule, the affection subsides rapidly under this treatment, combined with that appropriate for secondary syphilis in general, and the new nail grows again without any marked deformity.

TUBERCULOUS ONYCHIA.

Tuberculous onychia is often termed **onychia maligna,** and is a disease which occurs in infancy or adolescence. In scrofulous people a traumatic onychia frequently develops into this form, instead of getting well, as would be the case were the patient healthy. The disease, which may involve several fingers, gives rise to a livid swelling, at first at the base of the nail and, later on, spreading around it. This swelling ulcerates and fungates, the nail becoming black and soft, and falling off; or the condition may begin with an abscess beneath the nail, which falls off and leaves an ulcerating surface beneath.

Treatment.—The nail should be removed, the softened tissue thoroughly scraped away, and the part sponged over with undiluted carbolic acid. The best dressing to use at first is wet gauze sprinkled plentifully with iodoform, with a piece of mackintosh outside, which keeps it moist and forms an antiseptic fomentation. When the parts assume a healthy aspect, boric ointment (one-quarter the pharmacopœial strength) may be substituted. In addition to this local treatment, the general treatment for tuberculosis, already referred to in Vol. I. p. 231, must be carried out.

TUMOURS.

SUB-UNGUAL EXOSTOSES.—This is the term applied to little tumours which grow beneath the nails. In some cases, however, they are not really exostoses, but are fibromatous or papillomatous in nature; in some cases they are sarcomatous. They press up the nail and cause a great deal of pain. Strictly speaking, a sub-ungual exostosis is not an affection of the nail at all.

Treatment.—The only satisfactory method is to remove the nail and cut or gouge away the tumour; if there be a suspicion that the growth is malignant, amputation of the toe should be performed.

CHAPTER III.

AFFECTIONS OF THE LYMPHATIC VESSELS.

INJURIES.

WOUNDS of the lymphatic vessels only come under notice when the larger trunks are injured. Should this happen in an open wound, there is a free escape of lymph from the injured vessel and the condition known as *lymphorrhagia* is produced. This may lead to the occurrence of a fistula, from which lymph escapes, and which is very difficult to heal. As a rule, however, although in many operations a large number of lymphatic vessels are divided, there is very little trouble of this kind. The discharge of lymph may be copious at first, but it quickly diminishes, and in about eight days the vessels become sealed and the wound heals.

Treatment.—There is nothing special to be done for these cases beyond the ordinary wound treatment, except when the thoracic duct is injured (*vide infra*).

WOUND OF THE THORACIC DUCT.—In these cases there may be a great deal of difficulty in arresting the flow of lymph and getting the wound to heal. The injury is most likely to occur during the excision of adherent lymphatic glands at the base of the posterior triangle of the neck. It is recognised by the free flow of chylous fluid which wells up into the wound.

Treatment.—One of two courses may be adopted: (1) The end of the duct may be ligatured, or, as happened in one of our cases in which there was a lateral opening into the vessel, the wound in the duct may be sewn up with fine catgut, or (2) the wound may be left, the skin closely stitched up, and healing by first intention aimed at, a large sponge or sponges being incorporated with the dressing, so as to maintain pressure upon the part; this pressure should be reinforced by an elastic bandage applied outside the dressing. Although at first sight it may seem a serious matter to tie the duct, experience shows that this is

not the case, and apparently the vessels on the right side suffice to carry on the circulation. This is therefore the best method of treatment if it can be carried out. It will seldom be possible to unite the divided ends. When the duct cannot be ligatured, the second method of treatment must be employed.

OBSTRUCTION OF LYMPHATICS AFTER INJURY. —In some cases where there has been extensive interference with the lymphatic return from a limb, as, for example, after removal of the contents of the axilla in extensive cases of cancer of the breast, the obstruction to the lymphatics may be so great as to cause considerable and very obstinate *œdema* of the limb.

A somewhat similar condition occurs in these cases as a result of recurrence of the growth either in the lymphatics or in the axilla. In this case there is generally also considerable pressure upon the main veins. This gives rise to the so-called 'brawny arm' of cancer.

Treatment.—Under these circumstances the best treatment is to elevate the limb on every possible occasion, and to employ gentle rubbing and upward squeezing so as to help onwards the flow of lymph, and to bring about dilatation of the collateral channels. As a rule, the œdema is found to subside gradually after two or three months, and ultimately it may completely disappear. The operation of lymphangeioplasty may be performed in those cases where the œdema is persistent.

Lymphangeioplasty.—This name has been given to an operation in which a number of silk threads are introduced into the œdematous limb or organ, in which they remain permanently buried. The threads are carried from the affected area to one in which the lymphatic circulation is intact. The theory of the operation is that, since the lymphatics in the affected area are obstructed and unable to drain off the fluids, the threads will carry the fluid by their capillary action to the healthy region whence it will pass to the circulation. The operation has been performed for the relief of the swollen arm which follows amputation of the breast, for the relief of elephantiasis, and to drain a hydrocele or ascites into the subcutaneous tissues.

In the case of a limb, the first essential for success is the absence of any septic material, and inasmuch as this is very liable to accumulate in the furrows between the folds of the hypertrophied limb, especial care must be taken to disinfect the parts thoroughly.

At the distal end of the limb a small incision is made into the subcutaneous tissue along which a long probe is passed as far as possible parallel to the long axis of the limb towards the trunk. The eye of the probe projects at the first incision and is threaded with thick silk (size 4). An incision is then made over the point of the probe, which is withdrawn through this opening so that the silk comes to lie in the track of the probe. The probe is then re-inserted at this opening, pushed

further up the limb and, when introduced as far up as possible, a fresh incision is made over its point and the silk is pulled through in a similar manner from the second to the third incision, and so on until the end of the silk is buried in normal subcutaneous tissue above the swollen part. The silk should not be allowed to touch the skin at any point in its passage from one incision to the other, and the end lying in the first or most distal incision should be wrapped up in a piece of sterile wet gauze until it is buried in its turn beneath the adjacent skin. All the small incisions are closed by sutures. Three, four, or more silk threads or sets of threads, if preferred, may be introduced in a similar way and parallel to one another through separate series of incisions.[1] Careful measurements of the circumference of the limb should be taken before and after the operation, to determine how much shrinkage takes place subsequently.

The precise value of this operation and its ultimate place in Surgery cannot be definitely determined at the moment.

INFLAMMATORY AFFECTIONS.

Under this term may be included acute and chronic lymphangitis due to various causes, and elephantiasis.

ACUTE LYMPHANGITIS.

This is practically always a septic disease, and represents the reaction of the walls of the lymphatic vessels to contact with irritants absorbed by them from some seat of primary infection. Generally the affection is due to the organisms themselves ; sometimes, however inflammation may arise from the irritating products of the organisms alone. *Acute septic lymphangitis* is never a primary disease ; it is always secondary to some focus of infection, which may be either an external wound, or some inflammatory condition such as a boil. Among external wounds, the most serious are those inflicted during *post mortem* examinations, especially of septicæmic cases ; here the infection is often of extreme virulence, and the condition soon passes beyond a mere lymphangitis. Conditions of ill-health, such as alcoholism, starvation, diabetes, and so forth, especially predispose to the more severe forms of lymphangitis.

In acute lymphangitis the walls of the vessels become inflamed and thickened, and inflammation also occurs in the tissues around, giving rise to the condition known as peri-lymphangitis. When suppuration takes place, the pus is usually present outside the vessels as well as within them ; this suppuration is localised and generally occurs at intervals along

[1] See Sampson Handley, *Lancet*, Jan. 2, 1909, and *Brit. Med. Journ.*, April 9 and 16, 1910.

the lymphatics. The organism producing this condition is usually the streptococcus pyogenes, and lymphangitis plays an important part in the multiplication of abscesses in diffuse cellulitis, and also in septicæmia and pyæmia.

SYMPTOMS.—The symptoms of lymphangitis may be very severe, and often commence within twenty-four hours after the injury, with shivering, headache, loss of appetite, high temperature, and the presence of red lines running from the wound or primary focus of inflammation towards the nearest lymphatic glands. These red lines are generally broader than the lymphatic vessels beneath, and are accounted for by the presence of peri-lymphangitis ; they are firm, slightly raised, and often tender on palpation. Abscesses may form as the result of the escape of micro-organisms from the vessels into the tissues around. Bullæ and patches of gangrene may also occur along the course of the lymphatics in very severe cases. In the simplest form there is merely a primary seat of inoculation or focus of inflammation, with red lines spreading from it, with or without swelling of the nearest lymphatic glands. When the virus is very potent the lymphangitis may be only slightly marked, and the organisms may pass on through the lymphatic vessels and reach the blood stream, and so set up rapid and fatal septicæmia. In bad cases of lymphangitis, the fever, though at first of the acute sthenic form, soon assumes the typhoid type, and in the severest forms the patient may die in from one to four days.

Among the **complications** of this condition may be mentioned diffuse cellulitis, phlebitis, erysipelas, abscesses, and purulent affections of bursæ or joints, when the lymphatics pass over or are in the immediate neighbourhood of these structures.

TREATMENT.—**Prophylactic.**—Wounds of all kinds must be carefully cleansed. In *post mortem* wounds more especially, thorough disinfection with undiluted carbolic acid, as recommended in Vol. I. p. 164, should be systematically carried out as soon as possible after infliction of the wound.

Curative.—When lymphangitis is established, it is necessary to treat the primary source, the local affection itself, and the constitutional condition. **The primary source** should receive careful attention ; if it be a wound it should be thoroughly cleansed and sponged over with undiluted carbolic acid ; if a localised inflammation, such as a boil, it should be freely excised, or incised and scraped out, and the raw surface left should be swabbed with the acid in a similar manner.

The local affection itself is best treated by fomentations in its early stages (see Vol. I. p. 12). When the lymphangitis is very acute, it is sometimes advantageous to use fomentations of a warm watery solution of carbolic acid (1 in 40). Cyanide gauze soaked in this solution and not squeezed very dry is placed over the affected area, and outside it is laid a large piece of mackintosh or gutta-percha tissue overlapping it in all

directions. In this way heat and moisture are obtained, while at the same time the carbolic acid may be absorbed by the skin, and, passing along the same lymphatic trunks as the poison itself, may exert a direct action upon the organisms. This can hardly effect a true disinfection, but an attenuation of the virulence of the organisms may possibly be brought about by its means. If carbolic fomentations be employed, care must be taken not to cover too large an area with them, as otherwise a poisonous amount of the drug may be absorbed. It is further important to remember that carbolic acid should not be used when renal disease is present. In any case, the urine should be examined for carboluria, and if this or any other sign of carbolic acid poisoning be detected, the fomentations should be changed for those of boric acid.

When *abscesses* form or diffuse cellulitis occurs along the course of a lymphatic vessel, incisions must be made at once, and the treatment proper for acute abscess and diffuse cellulitis adopted; this has been already described (Vol. I. Chap. II.).

The constitutional treatment must also be attended to. The strength of the patient must be kept up, and stimulants should be given freely, with quinine in doses of ten grains every four hours until symptoms of cinchonism set in. The patient should have plenty of nourishing food, and the bowels should be kept acting regularly. The general treatment is identical with that already described for acute inflammation (see Vol. I. p. 14).

Antistreptococcic serum may be employed in these cases, and should be used without delay if it can be demonstrated by examination of the blood or of the discharges from the wound that the streptococcus pyogenes is the actual causal agent at work. Recently the so-called ‘ polyvalent serum ’—*i.e.* sera from animals immunised against several different strains of streptococcus—has been introduced, and will probably replace the older serum. The dose of the serum is usually indicated for each preparation, the ordinary one being 20 c.c. The general view is that large doses should be given, and should be repeated frequently; in the first twelve hours another 20 c.c. should be given, and then two or three further injections of 10 c.c. each at intervals of twelve hours. Injection of the serum may be followed by pains in the joints with some effusion or urticarial skin eruptions and severe itching, usually at the end of a week or ten days. The temperature may be slightly raised, and there is often some general malaise.

The point of primary importance in making the injections is to be sure that everything used is aseptic. Syringes are sold for the purpose which can be safely disinfected by heat. The syringe is boiled for at least a quarter of an hour immediately before use, and the skin at the proposed seat of injection is purified in the ordinary manner (see Vol. I. p. 99). After the injection has been made, for choice beneath the skin

of the abdomen or flanks deeply into the subcutaneous tissues, the syringe should be washed in water, and boiled for fifteen minutes.

Apart from the acute septic form just referred to, an *acute* or *subacute lymphangitis* may occur under other circumstances. For example there may be a *simple* lymphangitis in which the cause of irritation is not of a suppurative character, but in this form there are none of the symptoms characteristic of the acute form of the disease. Lymphangitis may occur in *gonorrhœa,* when it is due to the gonococcus. In *soft chancres,* lymphangitis sometimes, though rarely, occurs. It commences about the eighth day, and is characterised by red lines along the dorsum of the penis and the presence of a hard knotted cord, accompanied by œdema of the prepuce; an abscess may form in the course of the lymphatic vessels, and may lead to an obstinate ulcer with inoculable pus.

Treatment.—This is intimately associated with the treatment of the inducing cause and the ordinary treatment of inflammation.

CHRONIC LYMPHANGITIS.

Causes.—This occurs in the course of various other diseases, especially syphilis and tubercle, the lymphatic vessels being the principal channels by which infection reaches the system. In *syphilis* we may have affections of the lymphatic vessels in any of the three stages. In the primary stage the lymphatics on the dorsum of the penis may be felt as indurated moniliform cords without any pain or redness of the skin. In secondary syphilis thickened lymphatics may be found in various parts of the body, and they may also be met with in the tertiary stage.

In *tuberculosis* also there is a tuberculous lymphangitis, in which the vessels leading from the tuberculous lesion, especially if in the skin, are thickened and nodular, and these nodules may develop into scrofulous gummata (see p. 18). This condition may also extend to the thoracic duct, and it then leads to general tuberculosis.

Chronic lymphangitis plays an important part in the development of elephantiasis, chronic œdema of the limbs, etc.

Treatment.—The treatment of all these conditions is essentially that of the primary disease that induces them; in syphilis, the only treatment necessary is to administer remedies appropriate to the syphilis itself. The treatment of tuberculous lesions of lymphatic vessels, especially of the so-called scrofulous gummata, has already been alluded to (see p. 18). It consists essentially in excision of the tuberculous nodules wherever possible, and the employment of tuberculin (see Vol. I. p. 522).

Apart from the removal of the cause, the various methods suitable for chronic inflammation should be used, especially counter-irritation and pressure. In the extremities massage, bandaging and elevation of the

limb should be employed in order to combat the œdema (see Vol. I. Chap. I.).

The only form of this affection requiring special notice is elephantiasis.

ELEPHANTIASIS is an affection characterised by an enlargement of parts due to inflammatory œdema especially connected with the lymphatic vessels. In addition to the distension of the tissues with fluid, there is hypertrophy of the skin and subcutaneous tissues and not uncommonly of the other structures of the limb as well.

Varieties.—There are two distinct varieties of this affection.

The Non-parasitic Form.—This is usually inflammatory in origin and is the form most common in this country. In it there is lymphatic obstruction and a local inflammatory state of the tissues. Tuberculosis of the lymphatic vessels and glands is sometimes the cause of this condition, and it is almost always found to some degree in patients with chronic ulceration of the leg or chronic eczema, or in those who suffer from repeated attacks of chronic lymphangitis. Sometimes a whole limb, generally the lower one, becomes enormously enlarged without any apparent cause, the subcutaneous tissues become firm and solid and do not pit on pressure, or only very slightly, and then the skin and underlying tissues become hypertrophied; the former becomes coarse and is often thrown into large folds and irregular masses. Warty growths develop, and chronic ulcers may arise as a result of the accumulation of septic material between the folds of the skin.

The Parasitic Form.—In the second variety the invasion of the lymphatic vessels by a parasite, the *Filaria sanguinis hominis* leads to an enormous hyperplasia of the tissues from which they derive lymph. The adult worms inhabit the larger trunks and are of considerable size. The embryos, on the other hand, are microscopic, and are remarkable for their habit of appearing in the blood only at night. Although some obstruction may be caused by the worms themselves, the most important factor in the causation of elephantiasis is the chronic lymphangitis and thrombosis of the larger lymphatic trunks produced by them. The whole of the tissues of the part affected are enlarged, but the main part of the swelling is due to the hyperplasia of the skin and subcutaneous tissues. Warty growths are common, and there are a number of deep clefts between them in which dirt and the secretions of the skin accumulate. In consequence of this, ulcerations occur, which heal with difficulty, owing partly to the impossibility of keeping the part clean and partly to the deficient vascular supply. The parts usually affected are the legs and the external genitals in both sexes.

Course.—The endemic form is generally characterised by an acute onset, which often takes place after fatigue or injury, with the occurrence of lymphangitis, a certain amount of fever, headache, vomiting, redness and swelling of the parts, etc. This subsides, and after an interval further attacks may occur, and so it goes on until the condition of elephantiasis is

established. In the legs, the condition is generally unilateral, and the foot is usually most markedly affected, but it may reach up the limb as far as the groin. It does not cause much inconvenience, except from the weight of the enlarged part, which, however, may in time reach an enormous size. In the external genitals, the parts chiefly affected in men are the prepuce or the scrotum: chylous hydrocele may sometimes be present. In women the labia majora, and more rarely the clitoris are the chief parts involved.

Treatment.—This is very unsatisfactory. *Pressure* may be applied by means of an elastic bandage, and *massage* may be tried night and morning, but the results are not encouraging. *Ligature* of the main artery of the limb has been practised, with only transient success. Compression of the main artery does not give better results. *Punctures* into the part are useless and expose the patient to the risk of erysipelas, which is apt to develop after slight injuries in parts affected with elephantiasis. *Prolonged rest* in bed or elevation of the part leads to a diminution in the size, which is only temporary. In most cases the question of *removal* of the enlarged part arises; it is frequently required when the scrotum, the prepuce or the external genitals are affected, and sometimes *amputation* of the limb is necessary. Recently *lymphangcioplasty* (see p. 33) has been performed, in some cases with a good result, but in others without any permanent benefit.

In the parasitic form little can be done. Radical treatment of this disease is not yet possible, but palliative measures may afford some relief. In the early stages the size of the limb may be controlled to a small extent by the use of an elastic bandage. When the disease is fully developed the size of the affected part may be reduced by operation. In the leg, longitudinal strips including any marked prominences may be excised. In the case of the scrotum, an amputation of the main mass of the tumour has been practised with advantage. An attempt has been made to remove the parent worms with a certain measure of success. Although the established disease is not very amenable to treatment, the increase in the knowledge of the habits of the Filaria, which is accumulating, affords ground for hope that much may be done in the way of prophylaxis.

TROPHŒDEMA.

Under this name Mèige has described a group of cases in which there is œdema, usually of the lower extremities, but occasionally of other parts of the body. The œdema is due partly to fluid which can be removed temporarily by massage or pressure, and partly to an overgrowth of the subcutaneous tissue. In infants the œdema is more fluid than in adults.

This disease often runs in families and may be (see Fig. 11, *A*), present

at birth; more often it manifests itself at puberty. It has been known to follow an injury.

The swelling differs from hemi-hypertrophy in that the bones are not enlarged, and, in marked contradistinction to filarial elephantiasis, has no tendency to affect the genitalia. The skin is subject to ulceration as in other types of lymphatic obstruction (see Fig. 11, *B*).

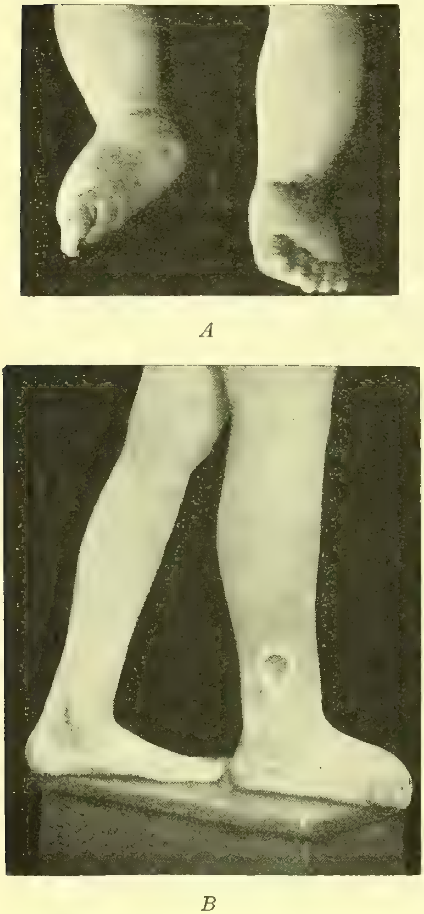


FIG. 11.—TROPHŒDEMA. *A* shows the condition in a young child, *B* the condition of a girl of 17 in whom there was an ulcer on the affected side.

Treatment.—This is as unsatisfactory as that of other types of lymphatic obstruction, and only palliative means can be employed. It should follow the lines laid down for the treatment of simple lymphatic obstruction (see p. 33); ulcers must be treated on the general lines laid down in Vol. I.

LYMPHANGIECTASIS.

This is a varicose condition of the lymphatic vessels. It may follow upon inflammations which obliterate or strangulate the main vessel, or upon pressure from bandages, cicatrices, etc., but in these cases the vessels seldom attain any great size, and do not become markedly varicose. The most common cause of the typical varix of the lymphatic vessels is the presence of the *Filaria sanguinis hominis*, and this condition is usually met with in the scrotum, where it is known as **lymph scrotum,** and in the groin, where it is termed **lymphadenocele.**

In lymphangiectasis there are distended tortuous tubes which may be both felt and seen, and the affected area becomes swollen and somewhat œdematous. When the lymphatics of the skin are attacked, vesicles may appear over the course of the vessels, and these often burst and lead to an exudation of lymph, sometimes in large quantity. Lymphadenocele is generally bilateral, and is characterised by the presence of a soft fluctuating swelling in the groin.

TREATMENT.—Of Lymphatic Varix.—Excision of the varicose trunks is not to be recommended. The varicosity is due, not to the pressure of a column of fluid or to inflammation of the vessels, but to actual obstruction, and the removal of the lymphatic trunks will not remedy this. On the contrary, it is apt to lead to lymphorrhagia. Mr. Godlee and Sir Patrick Manson have introduced a promising method of treatment for this condition by anastomosing prominent dilated lymphatics with a neighbouring vein (see *Clin. Soc. Trans.*, vol. xxxv. p. 209). It is difficult, but is well worth trying, as they report considerable improvement in the two cases in which it was tried. The operation of lymphangeioplasty (see p. 33) also seems to promise considerable improvement. Apart from these plans, the treatment must be palliative, and should consist in careful **support** and **compression** of the part with elastic bandages or strapping (the exact method depending upon the seat of the trouble) and massage.

Of Lymphorrhagia.—In cases marked by severe lymphorrhagia—a condition which is injurious from its tendency to produce anæmia—it may be permissible to **excise the affected area** if it be limited, in order to get healing by first intention. When this is done successfully, enlargement of the subcutaneous lymphatic vessels generally occurs. The operation must be done under rigid asepsis because acute and often fatal lymphangitis is likely to ensue, if septic material gain access.

Of Lymphadenocele.—This affection has been successfully treated by complete **excision,** and this method therefore should be followed by those who are confident of their power to keep the wound aseptic. The occurrence of sepsis in a wound of this kind would probably be disastrous; at the least, a permanent lymphatic fistula would be likely to form, and there is also a great risk of erysipelas or some other form of septic infection gaining access to the wound. In the cases not treated by excision, **pressure** should be employed by means of a pad and an elastic spica bandage.

TUMOURS.

Lymphangioma has already been referred to in speaking of tumours (see Vol. I. p. 264). It is not uncommon for **cancer** to occur in the lymphatic tracts leading from the primary disease to the nearest lymphatic glands, and special reference is made to this point in connection with cancer of the breast.

CHAPTER IV.

AFFECTIONS OF THE LYMPHATIC GLANDS.

WOUNDS.

Wounds of lymphatic glands are unimportant, and demand no special treatment.

INFLAMMATORY AFFECTIONS.

These may be divided into septic adenitis, acute and chronic ; the various forms of venereal adenitis ; and tuberculous disease of glands.

ACUTE ADENITIS.

Acute adenitis, with or without suppuration, is a very common affection, infective material being transported by the lymphatic vessels to the glands from all sorts of injuries and diseases of the skin. When this infective material contains pyogenic organisms, acute suppuration of the gland is very apt to follow. Noticeable lymphangitis is not necessarily present, and the adenitis may occur some time after the wound at the site of infection has healed, a small scar being left to indicate its presence. In these cases the gland, which is at first enlarged, reddish and firm, becomes soft and friable, and generally contains a number of foci of suppuration. Peri-adenitis rapidly occurs, the pus escapes through the capsule of the gland into the tissues around, and then, as in other acute abscesses, gradually spreads towards a free surface. When the abscess is opened, portions of the gland are usually found at the bottom of the wound, and if these be examined, independent foci of suppuration can often be seen in them.

SYMPTOMS.—The symptoms of acute adenitis are those of acute inflammation in general, with the addition of the local symptoms due to the affection of the glands. An acute aching pain is the first symptom, and a single gland is usually affected at first, but later on others in the

neighbourhood become enlarged, soft at first, tender and painful, and, after a time, matted to the surrounding parts as a result of peri-adenitis. If no suppuration occur, the pain generally subsides in the course of a few days, and the swelling gradually goes down, though it may be some weeks before it disappears entirely. Should suppuration occur, the glands become fixed, the skin reddened over them, and fluctuation soon becomes evident. As a rule, suppuration does not take place until the sixth or seventh day ; it usually results in a circumscribed abscess, but sometimes, especially in the neck, a diffuse cellulitis may be set up.

TREATMENT.—The treatment, in the early stage before suppuration has commenced, is that of acute inflammation (see Vol. I. Chap. I.) ; in addition, any primary focus giving rise to irritation of the glands should be treated. Inflamed ulcers should be disinfected, boils should be incised, and so on. Warm fomentations (see Vol. I. p. 12) should be applied over the gland, the parts kept at rest, if necessary on a splint, and the general treatment attended to.

When an **abscess** forms in connection with the gland it should be opened like any other acute abscess (see Vol. I. p. 27). Besides simply incising the abscess, however, it is well to remove the remains of the gland, because there may originally have been several foci of suppuration in it, and, although the main one is opened, the others may subsequently enlarge and keep up the suppuration. Hence an incision in the line of cleavage of the skin (see Vol. I. p. 134) large enough to admit the finger should be made, and if portions of the gland be felt at the bottom of the wound, they may be enucleated by the finger aided by a sharp spoon ; it is not necessary to make an elaborate dissection for the purpose. The resulting cavity should be drained; as a rule healing will occur in the course of a few days. This method does not apply to the acute form of adenitis due to venereal causes, which is described separately (see p. 45).

CHRONIC ADENITIS.

Chronic adenitis may follow on or precede the acute form, and is not uncommonly associated with uncleanliness, lice, eczema, ulcers, etc. When the cervical glands are affected, the presence of enlarged tonsils and adenoids should be looked for, and the state of the mouth and teeth should be investigated. Oral sepsis is frequently present in these cases. If the enlargement persist for some time, or increase in size, it will frequently be found, on excising the affected gland, that the condition is a tuberculous one ; secondary tuberculous infection is very prone to occur in these chronic cases.

TREATMENT.—If a primary source of irritation can be found, it should be removed at once ; for example, an eczema, oral sepsis, or an open ulcer, should receive appropriate treatment ; while, should the condition arise from lice or uncleanliness, the removal of the cause is all that is

called for. If the glandular enlargement be simple, it will then subside without any special local treatment; at most some *placebo* may be applied, the part being, meanwhile, placed at rest. The use of iodine and friction should be avoided. When, however, the enlargement of the glands continues or increases after the removal of all primary sources of irritation, there will be strong grounds for suspicion that the condition is tuberculous, and appropriate treatment (see p. 47) must be adopted accordingly.

VENEREAL ADENITIS.

Under this term are included simple bubo, arising in connection with want of cleanliness, and also gonorrhœal, chancrous, and syphilitic buboes.

SIMPLE BUBO.—This is an enlargement of the inguinal lymphatic glands, and results from some irritation, such as slight abrasions, balanitis, or uncleanliness. The enlargement of the glands is not accompanied by great pain or tenderness, and does not usually end in suppuration. It subsides quickly if the patient be kept at rest, with fomentations applied to the enlarged glands, and appropriate treatment to the primary source of irritation.

GONORRHŒAL BUBO.—Enlargement of the inguinal lymphatic glands occasionally occurs in gonorrhœa. It does not usually end in suppuration, however, unless septic organisms have gained access. When suppuration does occur, it is probable that there is infection by pyogenic organisms in addition to the gonococcus. In these cases it is generally possible to detect an intra-urethral sore by means of the urethroscope.

Treatment.—The treatment of gonorrhœal bubo is practically the same as that of the simple variety. The patient should be kept in bed so as to ensure complete rest to the part, and the treatment suitable for inflammatory conditions generally, viz., fomentations, a purge, etc. (see Vol. I. Chap. I.), should be adopted, and attention should be paid to the treatment of the primary condition. If irritating injections have been employed, these should be discontinued for a time, but the urethra may be washed out two or three times daily with tepid water, or very dilute Condy's fluid. Large quantities of diluents should be given by the mouth, and copaiba or sandalwood oil should be administered; in other words, the ordinary treatment for gonorrhœa must be adopted. When suppuration occurs, the treatment is similar to that for acute adenitis with abscess (*vide supra*).

CHANCROUS NON-SYPHILITIC BUBO is very common, a large number of cases of soft chancre being complicated by adenitis. Generally one or two glands at the inner end of the horizontal inguinal group are affected and the trouble begins about fourteen days after the appearance of the sore.

The symptoms of a chancrous bubo are usually sub-acute. They

may be acute, however, and in most cases suppuration ensues early. The suppuration begins in the substance of the gland, giving rise to an oval swelling with its long axis parallel to Poupart's ligament; this gradually softens and points. The pus is somewhat thin and dark, and contains flakes or clots; it is unlike the ordinary yellow pus of an acute abscess. If the abscess be opened freely, it often happens that a chancrous ulcer forms in the groin, which may extend deeply and prove extremely obstinate in healing.

Treatment.—This is somewhat difficult, especially when suppuration has occurred.

In the early stages, when the inflammation is not very acute, *compression* is useful. A large pad of cotton wool is laid over the inflamed glands, and kept in place by a firm spica bandage, outside which a piece of elastic webbing is applied so as to exercise gentle pressure. The patient should be kept recumbent, and the primary sore should receive appropriate treatment. The condition may subside entirely under this treatment. Injections of carbolic acid, or similar antiseptic substances, into the glands at an early stage are not to be recommended.

When the affection is progressive, however, the question as to the further procedure is somewhat difficult. Bearing in mind the obstinacy of the ulcer which follows free incision of these abscesses, and also the fact that fresh glands are apt to enlarge, and thus lead to the formation of ulcerating cavities in the groin, it is advisable to *excise the affected gland*, and, with it, any others in its vicinity that may be enlarged as soon as it is evident that softening of the glands is about to occur. If care be taken not to come too near to the infected gland, and more especially to avoid puncturing it during the operation, it is not uncommon for the wound to heal by first intention, and thus the patient is saved a prolonged and tedious illness. When the glands are not adherent to the skin, a semi-lunar flap, consisting of skin and fascia, may be raised; but if the skin be thinned, or even reddened, the affected portion should be included in an oval incision and removed, special care being taken to keep wide of the glands. The incision should be carried through the fat in the groin above and below the affected area, and the whole mass of fat and glands removed without the latter being exposed. It is generally well to insert a drainage tube for two or three days.

If there be a large abscess when the case is first seen, excision of the glands is not advisable, because the affection is wide-spread, and an extensive dissection would be required, and also because the abscess would probably burst during the operation, and infect the wound. Under these circumstances it is best to *open up the bubo* by as small an incision as possible. The organism that causes soft chancre is aërobic, and, as long as the skin is unbroken over one of these glandular abscesses, the condition progresses comparatively slowly. As soon as the interior is freely exposed to the air, however, a large chancroid ulcer forms rapidly.

Hence, access of the air to the interior should be hindered as far as possible. Two methods may be employed, the first being more to be recommended in the early stages. In both, the operation must be carried out with strict antiseptic precautions.

(1) An incision is made into the abscess just large enough to admit a Barker's small flushing spoon (see Fig. 12). The pus is allowed to escape, and the spoon attached to an irrigator containing a 1 in 4000 sublimate solution is introduced. The abscess is then flushed out thoroughly and the remains of the gland scraped away. The abscess cavity is squeezed dry and then filled with a 10 per cent. emulsion of iodoform and glycerine,[1] or a 10 per cent. emulsion of iodoform and vase-

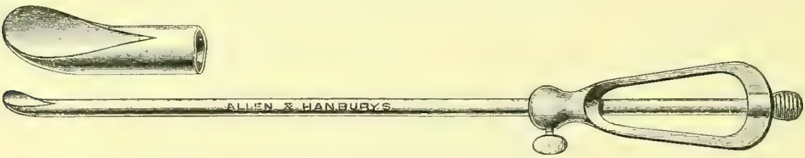


FIG. 12.—BARKER'S FLUSHING CURETTE.

line, liquefied by heat; an antiseptic dressing is afterwards applied, no stitches being inserted. In some cases the wound heals without further trouble.

(2) An incision is made, the pus evacuated, the interior scraped and washed out as before, and then sponged with undiluted carbolic acid. A small drainage tube is inserted, and antiseptic dressings are applied. The subsequent treatment, as regards dressings and drainage tube, is the same as in acute abscess.

If the wound tend to enlarge and become chancrous, it must be laid open freely, all sinuses or diverticula slit up, the surface scraped and nitric acid applied and its action neutralised after about five minutes by carbonate of soda solution (see Vol. I. p. 63); the cavity is stuffed afterwards with cyanide gauze impregnated with iodoform. At first the superficial dressings must be renewed daily, but the packing need not be taken out for some days if it adhere firmly to the wound. Later on, the dressings will need changing at less frequent intervals and, finally, weak boric ointment may be substituted when the cavity has become filled with granulation tissue.

SYPHILITIC BUBO.—Syphilitic affections of the glands may occur in any stage of the disease. In the *primary* stage the adenitis generally begins from the fourth to the tenth day after the appearance of the sore; it is usually bilateral, and several glands are affected, the one nearest the chancre being usually the largest. There is no tendency in these cases to suppuration. The *secondary* form of adenitis affects the glands else-

[1] Made by adding 1 part of sterilised iodoform to 9 parts of sterile glycerine. The iodoform is sterilised by keeping it submerged for some days in a 1 in 20 watery solution of carbolic acid.

where, the most common seats being the glandulæ concatenatæ, the suboccipital and epitrochlear glands which become enlarged and firm. Small sclerosed glands are also sometimes found in the *tertiary* stage; a gummatous condition has been described, but is very rare.

Treatment.—The treatment of these conditions is the general treatment of syphilis (see Vol. I. Chap. XI.), no local treatment being called for.

TUBERCULOUS ADENITIS.

Tuberculosis is a very frequent and important form of glandular disease. It most commonly occurs before twenty years of age, but is not uncommon at other ages, and is even met with at an advanced period of life. The glands most commonly affected are the cervical, the bronchial and the mesenteric groups. The glands are frequently affected secondarily to tuberculous ulcers on the skin or mucous membranes. In the case of the cervical, bronchial, and mesenteric glands, however, there may be no lesion at the point of entrance of the bacillus, the virus passing straight through the mucous membranes to the glands.

In the earlier stages of tuberculous gland disease there are found small discrete tubercles which subsequently run together, undergo softening, and then lead to a chronic abscess; they may, however, become caseous and gradually diminish in size, being finally impregnated with calcareous salts. Although from external examination only one or two glands may appear to be enlarged, as a rule a large number are affected; this is an important fact to bear in mind.

The glands form ovoid, firm, indolent masses, which are often painless, and at first freely mobile. At a later stage peri-adenitis may occur, and then the glands become matted together and gradually form a large lobulated or nodular mass. This is, perhaps, the most usual condition, at any rate it is common when suppuration is about to occur. In a still later stage the glands undergo softening, the capsule is broken through, and the disease spreads in the cellular tissue and towards the skin in the manner described in speaking of chronic abscess (see Vol. I. p. 233). When these abscesses burst, they leave tuberculous ulcers with sinuses leading down to cheesy glands. They are slow in healing, and very unsightly scars are left when this finally takes place.

All the stages of the evolution of the tuberculous process may be present in the same mass of glands.

TREATMENT.—We shall consider the appropriate treatment: (1) when the glands are isolated and there is no peri-adenitis; (2) when they have become matted together; (3) when abscess is present; (4) when abscesses have burst, and have left sinuses and ulcers.

When Peri-adenitis is Absent.—When the glands are isolated mobile and small, and there is no peri-adenitis or tendency to softening, no surgical interference is necessary at first. The **general treatment** of tuberculosis (see Vol. I. p. 231) should be attended to, residence at the

sea-side, or in a part of the country which suits the patient, the use of cod-liver oil, sea-water baths, and plenty of fresh air being the most important. These patients are often benefited by a prolonged stay at the seaside or in the country, but they must be kept under constant supervision, so that if an operation becomes necessary owing to the progress of the disease, the most favourable time for its performance may not be missed. Arsenic is of value in some cases ; the ordinary dose of liquor arsenicalis (which will vary according to the age of the patient) should be increased gradually until the patient is taking one just short of that necessary to produce toxic symptoms. The treatment by tuberculin (see Vol. I. p. 522) is very commonly employed for these cases. **Local applications** such as iodine are best avoided ; it is doubtful whether they do good, whilst they certainly seem to precipitate suppuration when peri-adenitis is present. Ointments cannot be recommended. When the glands are situated in parts of the body subject to movement, as in the groin, rest must be enjoined, and, if necessary, the part must be fixed with splints and bandages.

When, however, the glands are large, and cause deformity, or when they are increasing in size and number, it is advisable to excise them, even though they are not actually breaking down. This point is dealt with more fully in connection with tuberculosis of the cervical glands (see Vol. III.).

When Peri-adenitis is Present.—When the glands are becoming matted together into a large nodular mass, suppuration is apt to occur in some portion of it ; therefore, if the condition persists or increases after a short period devoted to a trial of general treatment, much subsequent trouble and unsightly scarring will be avoided by proceeding to *excise the glands* without further delay. It is true that a certain proportion of these cases recover perfectly under good hygienic conditions without operative interference ; but suppuration occurs in the large majority, and then the operation becomes very difficult. If, however, it be performed before an abscess of any size is present, no skin need be taken away, and a delicate linear cicatrix is left which becomes practically unnoticeable in course of time. The operation must be thorough ; not only should all the enlarged glands be removed, but with them should be taken all the smaller ones in the neighbourhood, even though they may not be visibly tuberculous. In order to get the most successful result, the whole of the fat and glands in the vicinity should be removed, if possible, in one mass. For example, in the case of the anterior triangle of the neck, all the fat and glands under the sterno-mastoid and along the course of the jugular vein should be dissected out. The steps of the operation for removal of tuberculous glands in the neck are described in full detail in Vol. III.

When there is an Unopened Abscess.—When the abscess is of moderate size, and does not involve any extensive area of the skin, the

best plan is still *excision.* Any thin or adherent skin should be enclosed in an elliptical incision and removed, and care should be taken to avoid puncture of the abscess during the dissection. Free removal of the whole lymphatic area must be practised, as partial excision or removal of visibly diseased glands only is very apt to end in disappointment; there is almost always enlargement of other glands subsequently, and this is especially likely to be the case if sepsis should occur. Under these circumstances, irritation and rapid enlargement of the smaller glands already infected take place. The surgeon should never be content with merely shelling tuberculous glands out of their capsules.

When the glandular abscess is very large, or when, as sometimes happens, there is a mixed infection with pyogenic organisms, an excision, practised when the case first comes under notice, would mean the removal of a large portion of the skin and would entail a very difficult dissection. In these cases it is probably best to open the abscess antiseptically first of all, introduce a drainage tube, and wait for the subsidence of the swelling. It will be found that the greater part of the swelling subsides in a few weeks' time, and a sinus is left leading to the mass of tuberculous glands. At this stage excision of the glands may be practised with advantage, the sinus being dissected out at the same time (*vide infra*).

There is not much to be said in favour of such *partial operations* for tuberculous glands as scraping with a sharp spoon. In this plan, a small incision is made over the gland, whether it be suppurating or not, and a sharp spoon is bored into it and the cheesy material or the pus evacuated. After the glands have been scraped out, the cavity is generally filled with glycerine and iodoform emulsion (see p. 46) and the wound stitched up without a drainage tube. Strict asepsis must be maintained, and if the wound gives way, antiseptic dressings will have to be continued until healing is complete.

The result is generally unsatisfactory; a certain number of cases do well, and recover with a small scar, but in a large proportion a sinus is left, fresh glands enlarge, abscesses form in connection with them, and ultimately the surgeon is compelled to excise the whole of the affected area. There is also a risk that acute tuberculosis may occur after scraping out tuberculous glands. Should the surgeon decide to employ scraping in preference to excision it is well to leave the glands unopened as long as possible, so that they may become completely broken down; he may then possibly succeed in scraping away all the tuberculous disease, and is not so likely to leave behind tissue that will infect the wound. Most of the cases in which a good result is obtained by scraping are those in which the glands have become completely broken down by the chronic suppurative process before operative measures are resorted to.

When a Sinus is Present.—When the patient comes under notice with sinuses leading down to diseased glands, *excision* of the mass is the best treatment. The operation is rather difficult, but if proper lines be

followed, such as are indicated for glands in the neck, it can usually be completed successfully. Since there is already a septic sinus present, however, the outer end of the latter should first be scraped, and then a piece of sponge or wool dipped in undiluted carbolic acid should be introduced into it, and left in as a plug. Then the skin is purified, and the sinus is enclosed in an elliptical incision, care being taken not to button-hole it in excising the mass of glands. As it is impossible to be quite sure that perfect asepsis has been secured, a drainage tube should be introduced into the wound at the end of the operation.

After-treatment.—The patient should be placed under the best hygienic conditions, and, after the wound has healed, should be sent to the country so as to re-establish the general health. Tuberculin in appropriate doses may be used as a prophylactic against a recurrence (see Vol. I. p. 522).

TUMOURS.

The neoplasms occurring in lymphatic glands may be either primary or secondary.

PRIMARY TUMOURS.

The primary tumours of lymphatic glands are rare, the chief being lymphadenoma or lymphoma. There is, however, some evidence to show that this disease is due to a chronic infective process and is not an example of true tumour formation. For the present, however, it will be more convenient to consider it here. Lympho-sarcoma which is also a primary tumour of lymphatic tissue is fully described in connection with Tumours (see Vol. I. p. 264).

LYMPHADENOMATA are composed of lymphatic tissue and occur primarily in glands or in parts where lymphatic tissue is normally found; they present the same structure as the lymphatic glands, that is to say, a delicate reticulum with lymphocytes entangled in it. These lymphatic tumours vary in malignancy, but the typical lymphadenoma is very malignant indeed. It occurs in glands, generally beginning in the neck or the axilla, and the growth of adenoid tissue quickly spreads beyond the gland capsule and infiltrates the tissues around. Adhesion of the gland to the surrounding structures soon occurs, and thus a nodular mass is formed composed of a multitude of glands united by adenoid tissue. Other groups of glands then become involved and, in addition, tumours composed of lymphatic tissue may appear in parts where this is not normally present, as, for example, in bones. The disease is accompanied by increasing pallor, but not at first by emaciation. Ultimately death takes place from exhaustion.

Treatment.—The treatment of lymphadenoma is unsatisfactory. Excision of a mass of lymphadenomatous glands seldom arrests the

progress of the disease, even, although the whole of the affected area may apparently be removed. Other glands soon enlarge and recurrence often takes place in the neighbourhood of the primary growth. Hence, except at an early stage, or where its situation is such that the growth causes much suffering from pressure upon important organs, excision cannot be recommended ; even at an early stage it is of doubtful value.

Various drugs are said to exercise a certain degree of restraining influence on the growth of these lymphadenomata, but the results obtained from their administration are unsatisfactory. The one usually ordered is *arsenic*, and it is most commonly given in the form of Fowler's solution beginning with three minims in water three times a day after meals and increasing it by one minim every day or two, so long as it can be borne without causing intestinal irritation, a condition which manifests itself by nausea, vomiting, colic, and diarrhœa. When this occurs, the arsenic should be left off for a few days, and when these symptoms have passed off, the drug may again be given in smaller doses, which should be cautiously increased. Some have advocated the injection of Fowler's solution into the tumour, quantities varying from two to six minims being introduced once a day. There is no convincing proof of the advantage of using the drug in this way. Abroad, *phosphide of zinc*, in doses of a twentieth of a grain in pill three times a day, is often ordered. On the whole, arsenic is probably the most efficacious drug, but permanent benefit can hardly be hoped for from it. Recently the X-rays have been used with some success, and injections with Coley's fluid (see Vol. I. p. 249) have been recommended.

LYMPHO-SARCOMA.—This is fully described in Vol. I. p. 264.

SECONDARY TUMOURS.

The secondary tumours of lymphatic glands are either sarcomata or carcinomata.

Treatment.—In all cases of cancerous disease the glandular tumour should be removed, if possible, and great care should be taken, as in the case of tuberculosis, not only to remove the visibly enlarged glands, but also the whole glandular area, which can only be done by making a complete dissection embracing all the glands and fat and removing them in one mass. This is most important, and is most easily carried out in the axilla and the neck, where glandular infection after disease of the breast or mouth is very likely to occur. Further, in cases of degenerating malignant glands, the greatest care must be taken not to rupture them, as otherwise the whole wound may become a diffuse malignant sore. Should the glands give way in the course of the operation and the semi-fluid cancerous material escape—as not infrequently happens in the case of epitheliomatous glands—the entire wound must be carefully swabbed out with undiluted carbolic acid so as to destroy all the epithelial cells.

CHAPTER V.

AFFECTIONS OF FASCIÆ.

TRAUMATIC AFFECTIONS.

INJURIES to the fasciæ are common and vary in degree from a simple 'sprain' to an actual rupture.

RUPTURE.

This is the most important of the injuries of fasciæ; for example, in the case of the foot, an overstretching or a sudden descent from a height on to the sole may lead to rupture of a portion of the plantar fascia. The injury is accompanied by great pain at the time, and sometimes imperfect union of the ruptured fascia may lead to much pain and tenderness whenever the patient bears his weight upon the foot.

TREATMENT.—The main object must be complete rest, so as to allow the ruptured fibres to unite. When the plantar fascia has been ruptured, the foot should be put up in plaster of Paris, with the instep fully arched by bending the toes downwards, so as to relax the fascia as much as possible. This casing should only be kept on for about a fortnight; if it be kept on too long, the fascia is apt to contract, and there may be difficulty in obtaining free extension of the foot afterwards. When the plaster has been removed, care must be taken to prevent any sudden strain or great weight being thrown upon the arch of the instep for some time. Massage is useful.

CONTRACTIONS.

These may result from a disease, such as gout, or may be due to repeated, long-continued, and severe pressure or to prolonged immobilisation of the limb in a faulty position. The most marked example of a contraction of the fascia due to disease is that known as **Dupuytren's contraction** of the palmar fascia, which is frequently associated with gout

or rheumatism, and which has been already described (see Vol. I. p. 289). Contraction of the fascia from pressure is also seen in the hand, as the result of using instruments which constantly exert pressure on a particular part of the palm. Probably a certain amount of inflammation is set up in this way, and this leads to contraction of the fascia. A similar condition produced by immobilisation is sometimes met with after fractures or joint disease, while the effects of prolonged faulty position are well marked in cases of infantile paralysis, where, for example, the front part of the foot drops as a result of paralysis of the anterior muscles of the leg, and a secondary contraction of the plantar fascia follows and interferes with proper extension of the foot. In the case of fractures and joint disease, inflammation probably plays some part in the production of the contraction of the fascia, while, in the case of infantile paralysis, it may be largely a question of imperfect development.

TREATMENT.—As a general rule the contraction may be remedied by subcutaneous division. A tenotome, which should have a sharp point and a cutting edge of not more than a quarter of an inch in length, is introduced flatwise between the fascia and the skin while the parts are lax. The cutting edge is turned towards the fascia; this is put upon the stretch, and the part beneath the edge of the knife is divided by nicking it with the point. When one band has been cut, fresh resisting bands start into prominence, and so the knife is pushed on in various directions until all tight bands are divided. Sometimes the division can be completed through one puncture; generally a number of separate ones will be required. The contracted fascia usually consists of a number of tight bands, and not of an even continuous layer; it is therefore of importance to use a tenotome with a small cutting blade, and to do most of the division by nicking the contracted bands with the point, for fear of damaging important underlying structures. When as much as possible has been done by the knife, the part is thoroughly stretched, so as to tear any portions that may have escaped division, and the limb is put up in the stretched position in a suitable apparatus, or a plaster of Paris case is applied; this is kept on for some weeks or months, until, in fact, contraction in connection with the healing process has ceased. Detailed treatment for certain special cases, such as club-foot and Dupuytren's contraction of the palmar fascia, has already been given (see Vol. I.).

NEW GROWTHS.

New growths in connection with fasciæ are not uncommonly met with. The most frequent are **fibromata**, which often begin in the dense fibrous tissues. **Sarcomata**, more especially of the spindle-celled variety, also occur. The treatment of these has been referred to in Vol. I. Chap. XIII.

DESMOIDS.

The term desmoid is applied to a fibrous tumour originating in the muscles or muscular fasciæ of the abdominal wall. Nearly all the recorded cases have been in married women who have had children, and indeed the tumour may be first noticed during pregnancy or soon after labour. Occasionally they have been found in men. They are situated in the abdominal wall and may involve a large portion of the muscular bundles or the sheath of the rectus. They grow slowly and form firm painless masses, more or less oval in shape or flat like a plaque. Some degree of mobility across, but not in the direction of, the muscle fibres may be obtained, and when the muscle is made tense the tumour becomes fixed. Unless care be taken to remember the existence of these tumours, they are very likely to be diagnosed as intra-abdominal. To the naked eye on section, the tumour has a white appearance and the fibrous tissue is plainly visible. There is no capsule, and at the edge the growth can be seen extending into the muscle fibres. Microscopically they consist of spindle cells and fibrous tissue, the former being abundant at the growing edge, and the latter in the older parts of the mass. They resemble closely a spindle-celled fibro-sarcoma. Cystic and myxomatous degeneration may occur.

TREATMENT.—The tumour and the portion of muscle or fascia to which it is attached must be removed. When the tumour is adherent to the rib, the affected portion of the bone must be excised. Unless a wide removal of the structures involved be carried out, recurrence will take place. When a large portion of the abdominal wall is affected, removal may be impossible. No other treatment than by operation is likely to be beneficial.

CHAPTER VI.

AFFECTIONS OF BURSÆ.

WOUNDS.

THE bursal cavities are in close relation with the lymphatic vessels, and therefore any septic infection of them is particularly dangerous, and may lead to violent inflammation. For example, when the bursa over the olecranon has been punctured, enormous swelling of the arm with redness and œdema not uncommonly results. So great is the swelling in proportion to the damage done to the bursa, that, when the puncture is not obvious, it is difficult to arrive at a just estimate of the condition unless this fact be remembered.

TREATMENT.—When a bursa is wounded, care must be taken to disinfect the wound; the entire bursal cavity should be swabbed out with undiluted carbolic acid, the opening being enlarged, if necessary, whilst the skin around is disinfected in the ordinary manner. A drainage tube is then inserted into the cavity and antiseptic dressings are applied. The **after-treatment** must be conducted on the lines already laid down for the treatment of accidental wounds (see Vol. I. Chap. VII.).

If inflammation has already set in, the cavity must be laid freely open, sponged with undiluted carbolic acid, and packed with gauze; if the inflammation be very severe, warm boric fomentations (see Vol. I. p. 35) may be applied outside.

INFLAMMATORY AFFECTIONS.

An inflammation of a bursa may be acute or chronic.

ACUTE BURSITIS.

Acute bursitis occurs either as a serous or a purulent inflammation. It may follow contusions, especially if there has already been some chronic inflammation, or it may be secondary to some inflammation in its vicinity,

e.g., erysipelas of the skin or inflammation of a neighbouring joint. In some cases it is due to a direct wound. Acute bursitis may be due to gout, the bursa over the olecranon being most often affected ; a rheumatic form is also described.

TREATMENT.—*When Suppuration has occurred.*—The bursa must be laid open freely, drainage tubes inserted at the most dependent points, and an antiseptic dressing applied. It is often necessary for efficient drainage in a large bursa like the pre-patellar, to make two, or even more, counter-openings at its lowest points. In the pre-patellar bursa this is best done by a small median incision, through which the finger explores the cavity and directs a probe or pair of sinus forceps, which are made to project beneath the skin at the most dependent points, and are cut down upon for counter-openings. The neighbouring joint should be fixed with splints until the inflammation has subsided.

When suppuration has not occurred, the usual treatment for inflammation (see Vol I. Chap. I.) should be employed ; this will be rest and cold in the early stages, hot fomentations, leeches, etc., later on. If there be any rheumatic tendency, 20 grains of salicin or salicylate of soda should be given three times daily. The majority of cases of acute bursitis, however, go on to suppuration, and time is saved and a better result is obtained by early incision and drainage, even though no pus has formed, provided that the wound can be kept aseptic. The fluid evacuated under these conditions is thick synovia with flakes of lymph in it. A fine drainage tube (No. 5) is inserted between the edges of the wound ; this can generally be dispensed with after the third day, and the wound is then allowed to close. There is no need for counter-openings ; drainage through a median vertical incision will suffice. If the pre-patellar bursa be affected, the patient may be allowed to walk about with the knee fixed in a suitable casing.

CHRONIC BURSITIS.

Chronic inflammation of a bursa may follow upon the acute form, or it may be chronic from the first ; it is usually the result of a slight but frequently repeated contusion or injury. Its most common seat is the pre-patellar bursa, where it usually results from prolonged kneeling. Sometimes there is considerable pain and some redness of the skin in the early stage of the disease—a *subacute* inflammation in fact—but there is not the acute œdema and the violent symptoms characteristic of an acute suppurative inflammation. The pain soon subsides and leaves the bursa dilated and its walls thickened ; the subacute inflammation, however, is very liable to recur on the slightest provocation. In other cases, adventitious bursæ may develop over parts subjected to pressure, and these may inflame subsequently ; common examples of this are the bursæ which develop over the side of the metatarsal bone of the great toe in hallux valgus, and which are known as bunions.

As the result of the chronic inflammation, various changes take place in the wall of the bursa. In the early stages the bursal cavity is merely distended with fluid, and its surface becomes covered with lymph; this leads to thickening of the wall of the bursa, and the formation of bands crossing its cavity, or tags hanging into it; the latter may become detached, and form loose bodies. The chief cause of the constant recurrence of chronic bursitis, after it has subsided under treatment by rest and counter-irritation, is the presence of these loose bodies or tags in the bursa. As time goes on, the wall becomes more thickened and fibrous, until, ultimately, it may become converted into a fibrous tumour with a small cavity containing a little fluid.

TREATMENT.—**Radical.**—The treatment of chronic bursitis should be radical wherever it is possible. Undoubtedly the best method is to *excise* the sac entirely, and thus a great deal of time is saved. Excision, moreover, is essential, when the bursal wall is much thickened, or when there are bands or loose bodies present in the interior.

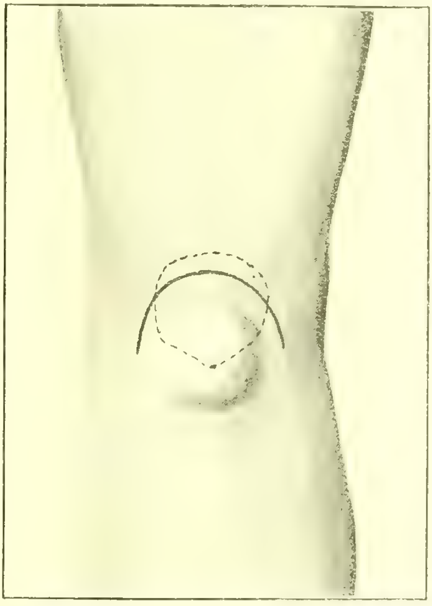


FIG. 13.—THE INCISION FOR REMOVAL OF THE PRE-PATELLAR BURSA. The unbroken line is the incision, the dotted one denoting the outline of the patella.

In excising a **pre-patellar bursa,** for instance, the skin about the front of the knee should be purified with scrupulous care, as, owing to the thickness of the epidermis, septic material is apt to accumulate there, and is only got rid of with difficulty. A curved incision with the convexity upwards should be made around the swelling, its upper border coming just below the upper limit of the patella, and its ends terminating a little to each side, well below the centre of the tumour (see Fig. 13). The flap, thus marked out, is turned down until the anterior surface of the enlarged bursa is fully exposed, and it is then easy to see the limits of its wall, and to detach it from the connective tissue around with a few strokes of the knife, and peel it off unopened from the front of the bone and the ligamentum patellæ. There is no danger of wounding the joint if care be taken to keep close to the sac. After the bursa has been removed, the wound is stitched up, an antiseptic dressing is applied, and the limb put upon a splint, or a thick mass of dressing applied so as to check the

movements of the joint sufficiently to permit rapid healing. The stitches may be taken out in a week, a collodion dressing applied, and the patient allowed to walk on the eighth day. The scar of the curved incision, recommended above, does not lie over the lower part of the bone, so that there is no danger of pressure upon the scar and pain on kneeling. The skin over the patella soon becomes supple, and the patient experiences no inconvenience from the absence of the bursa.

Palliative.—This should only be employed when the patient declines radical treatment ; it consists in *rest* and *counter-irritation.* The limb is placed upon a back splint, the patient being kept recumbent or only allowed to walk with the splint on, and iodine or blisters are applied over the bursa. Time may be saved by drawing off the fluid with an aspirating needle before applying the counter-irritation. If the patient continue to walk, only a slight diminution of the swelling results as a rule ; if, however, she be confined to bed from the first, the swelling may disappear almost entirely, the fluid being absorbed, and only a thickened bursal wall left. In many cases it is then possible to feel cords or loose bodies moving under the finger in the interior of the bursa. If the patient resumes kneeling, the effusion recurs, so that nothing is gained by this palliative method of treatment unless kneeling can be given up.

Other methods intermediate between complete excision and rest have been employed. For example, the bursa may be *aspirated* and *injected* with tincture of iodine or undiluted carbolic acid, as is done in the case of a hydrocele ; at least as much time is taken up by this method of treatment, however, as if excision were practised, and the result is uncertain. *Incision and drainage* will often cure the trouble permanently, even if loose bodies or tags be present in the bursal cavity, as they can be removed at the same time, but this plan does not possess any advantage over excision. In the first place, it takes longer (as a rule, it is not possible to leave out the tube in less than ten days, and then the wound has still to heal), and it is more dangerous on account of the risk of sepsis. If sepsis were to occur in the wound made for removal of the bursa (provided no communication had been made with the joint), it would probably be a purely local accident ; whereas, sepsis in an open bursa is followed by violent suppurative inflammation, which not only causes prolonged local trouble, but may lead to general septic infection. Recurrence of the original bursitis has taken place after incision and drainage.

TUBERCULOSIS.

This is not very uncommon, and the disease runs the ordinary course of tuberculosis elsewhere. The wall of the bursa becomes thickened, and effusion occurs into its cavity. The fluid often contains *rice or melon-seed bodies.* These are oval-shaped masses, white or yellowish-white in colour, and of a soft texture. Subsequently pus is developed, which

gradually finds its way to the surface. These bursæ may or may not be connected with and secondary to disease of the joint; those most commonly affected are the bursa over the great trochanter, and that beneath the deltoid muscle.

TREATMENT.—The treatment is essentially that of chronic abscess (see Vol. I. p. 233). The affected bursa and its contents should be dissected out if possible; when this cannot be done, the wall should be clipped away after the cavity has been laid open freely, and any portion that has to be left behind should be scraped and sponged over with undiluted carbolic acid.

When the entire bursal wall is not easily accessible, *e.g.*, in the **psoas bursa,** the pus should be evacuated, the walls scraped, the cavity injected with a 10 per cent emulsion of iodoform and glycerine (see Vol. I. p. 234), and the wound stitched up without a drainage tube. In the case of the **bursa over the great trochanter**, an incision should be made with its convexity forwards, and a flap turned back so as to expose the swelling completely. The bursal wall is then peeled off from the underlying tissues, and removed entire, the surface of the bone being carefully examined for evidence of tuberculous infection; any deposit of tubercle in it, must be gouged out. The wound is stitched up and an antiseptic dressing and pressure applied. On the other hand, it is impossible to remove the **subdeltoid bursa** entirely without an extensive dissection, but it is possible to dissect away the greater part of it by means of an incision along the anterior edge of the deltoid muscle, curving backwards at the lower part (see Fig. 14). The portion left behind should be scraped, iodoform and glycerine emulsion injected, and the wound stitched up without a drainage tube. Tuberculosis of the subdeltoid bursa is generally secondary to tuberculous disease of the shoulder joint, and if this be the case and the disease be extensive, it may be advisable to excise the joint. It will then be best to dissect away the bursa as completely as possible before dealing with the synovial membrane and the joint surfaces (see Vol. III.).

FIG. 14.—INCISION FOR REMOVAL OF DELTOID BURSA. This should correspond mainly to the anterior edge of the deltoid muscle, and should curve round well on to the outer aspect of the arm at its lower end.

SYPHILIS.

Syphilitic bursitis occurs in the *secondary* stage as an acute affection; in the *tertiary* stage it occurs as a gummatous deposit, but these lesions are rare. The pre-patellar bursa is most often affected and gummatous

disease of the synovial membrane of the knee is frequently present at the same time. If untreated, a typical ulcer surrounded by a good deal of induration forms in the situation of the bursa. The condition is often symmetrical.

TREATMENT.—The treatment is that for syphilis (see Vol. I. Chap. XI.).

TUMOURS.

New growths in the walls of bursæ are rare. *Sarcomata* and *myxomata* are met with occasionally, and at first may be difficult to distinguish from simple enlarged bursæ, the walls of which are merely thickened by inflammatory deposit.

TREATMENT.—This is similar to that of new growths elsewhere, and consists in complete removal of the tumour.

CHAPTER VII.

AFFECTIONS OF THE MUSCLES.

ATROPHY.

Atrophy of muscles arises from many causes, and is usually due to defective innervation, such as occurs after division of a motor nerve, central paralysis or peripheral neuritis. Atrophy is also a common sequel to disuse of muscles, and it may result from direct injuries, such as blows, when it is due to hæmorrhage into the substance of the muscle or to damage to the nerve supplying it. Atrophy also occurs in the muscles in the neighbourhood of joints which are the seat of tuberculous or rheumatic disease, and in these it proceeds more rapidly and extensively than can be accounted for by mere disuse of the articulation. Osteo-arthritis and traumatic arthritis are also accompanied by wasting of the muscles, and, in a lesser degree, atrophy is present in cases of congenital deformities of joints. After atrophy has gone on for some time, the muscles tend to shrink, and thus the tendons become tight, and may require division before proper restoration of the movements of the joint can be obtained.

TREATMENT.—This depends upon the cause of the atrophy. When it is some central nervous derangement little can be done beyond promoting the nutrition of the muscles; when the atrophy results from division of the motor nerve, nerve suture must be practised. Atrophy in connection with joint disease will persist until the condition of the joint so far improves that movements can be carried out freely, and even then some atrophy may remain permanently. Should atrophy supervene after an injury causing hæmorrhage into the muscles, the sooner the effused blood is got rid of, the sooner will the functions of the muscle be restored. Although the first point in the treatment is to find out, and, if possible, remedy the cause of the atrophy, much may often be done to prevent it, or at any rate check its spread and hinder

the shrinking of the muscle whilst the cause is being treated; the most useful methods for this purpose are massage, manipulations, and electricity.

Massage.—The principles of massage are explained in Vol. I. p. 23; the object is not to remove effused materials, but to improve the circulation in the muscle, and to stimulate the muscle-fibres to contract in order that they may regain a certain amount of power. Attempts to improve the circulation are best made by rubbing and kneading the muscle in the upward direction, and contractions are induced by repeated tappings and vibrations applied to the muscle itself. More important still are active muscular movements against resistance. The patient tries to move the limb against resistance applied by the masseur or some suitable instrument.

Electricity.—In employing electricity, the faradaic current should be used, except when there is some joint lesion, in which, therefore, contractions of the muscles might aggravate the mischief. An electrode three inches square and covered with chamois leather or thick flannel is soaked in warm salt solution and applied to the spine; while another electrode, not less than two inches square, is applied over the affected muscle and moved slowly all over it, in close contact with the skin. The current should be just strong enough to cause gentle contractions of the muscle, and not to give rise to pain. If preferred, the two electrodes may be placed side by side on the skin and moved about. Each sitting should last from ten to twenty minutes, and should be repeated every day or two for several months.

Manipulations.—At the same time frequent manipulations should be practised, with the view of stretching the muscles and preventing the occurrence of contractures, provided that the case be not one of joint disease in which movements would be harmful.

TRAUMATIC AFFECTIONS.

Injuries of muscles vary in degree from a simple contusion to complete rupture of the muscular fibres.

CONTUSIONS OF MUSCLES.

Contusions of muscles may sometimes give rise to considerable mischief. A contusion leads to infiltration of blood among the muscular fibres, which interferes with their action and often causes temporary paralysis. When struck, the muscle contracts, and this is followed by fibrillary twitchings, after which the muscle relaxes and may not recover its power for two or three days. When permanent paralysis of a muscle follows a blow, it is usually due to damage to its nerve supply rather than to injury of the muscular fibres themselves.

Hæmorrhage into a muscle may be followed by various troubles;

there may be adhesion of the muscular fibres to each other, or fibrosis and consequent impairment of function. In some cases calcareous salts are deposited in the muscle and calcification occurs; in others a true ossification may take place. Occasionally the effused blood is neither absorbed nor organised, but becomes encysted and forms a blood-cyst in the substance of the muscle.

TREATMENT.—The part should be placed completely at *rest* until the hæmorrhage has ceased; when this has occurred, attempts are made to get rid of the effused blood as rapidly as possible by the employment of suitable massage. *Massage* should consist at first, of gentle rubbing in the upward direction for about twenty minutes at a time twice a day. In a few days the other methods employed by masseurs for breaking up the exudation (see Vol. I. p. 23) may also be used. Each sitting should be gradually lengthened up to half or three-quarters of an hour at a time, and the massage should be persisted in for at least two or three weeks.

When the effusion is large and does not become absorbed readily, the best plan is to make a curved *incision* over one side of the swelling, expose the muscle, turn out the clots and put in a drainage tube for two or three days. The operation must be done strictly antiseptically on account of the danger of septic infection. Massage and manipulations should be employed as soon as the wound has healed.

WOUNDS OF MUSCLES.

Incised wounds of muscles are of no particular moment unless the incision be transverse to the direction of the muscular fibres

Punctured wounds over muscles often do not injure the muscle, as it contracts and slides out of the way, but occasionally some of the fibres are divided and retract, and leave an irregular gap in the muscle (see Punctured Wounds, Vol. I. Chap. VIII.). When the incision is large and, particularly, when it is transverse to the direction of the muscular fibres, considerable retraction takes place and serious functional disability may result unless means be taken to restore the continuity of the muscle.

TREATMENT.—When a muscle has been divided transversely through the greater part of its width, an attempt must be made to approximate the divided ends by means of sutures. This is a somewhat difficult task, for if the sutures be inserted in the same manner as they are in the skin, each one simply separates the muscular fibres and cuts its way out as the thread is tightened. In order to avoid this, the suture must be passed transversely across the muscle at some distance from the divided edge and tied so as to surround a mass of muscular fibre sufficiently tightly to prevent the portion included in the ligature from slipping through the loop, but not tight enough to strangulate its vessels (see Fig. 15). A similar stitch is put in the other divided end, and tied in a like manner. The ends of these two stitches are then tied together firmly, and thus the

divided ends of the muscle are approximated (see Fig. 15). Before the stitches are tied, the muscle should be relaxed by flexing or extending the limb according to the muscle affected. More than one suture may be required, the number being regulated by the breadth of the muscle. When these fixation stitches have been tied, the approximated muscular edges may be united by means of a continuous catgut suture, the button-hole stitch (see Vol. I. p. 142) being the best. Catgut is the best material for suturing muscles. A drainage tube should be inserted and the limb placed upon a splint in the position that ensures full relaxation of the muscle.

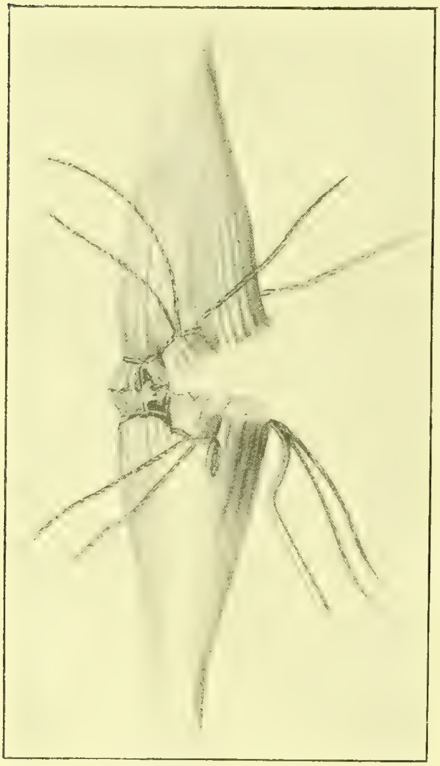


Fig. 15.—Method of Suturing a divided Muscle. The method of passing the sutures is shown in the right-hand side of the figure. On the left-hand side they are shown passed and tied.

After-treatment. — This should follow the lines laid down for accidental incised wounds (see Vol. I. p. 164). Full muscular relaxation should be maintained for three days, and then may be diminished daily until, in the course of a fortnight, the muscle is put fully upon the stretch. It is important not to keep the muscle in the fully relaxed position too long, because a certain amount of adhesion is likely to form between the line of suture and the tissues around, and if possible this should occur when the muscle is fully extended; the muscular contractions will then pull upon and gradually stretch the adhesions. The patient should move the muscle voluntarily in about four weeks, but up till then only passive movement should be resorted to. If firm adhesions should form between the line of union in the muscle and the other soft parts, massage and faradism are of great assistance in breaking them up; if necessary, they may be divided with a tenotomy knife. The uniting material is composed of fibrous tissue, but if the parts have been well approximated, and no separation occurs during healing, the line of union is narrow and firm, and the muscle is as good as ever.

RUPTURE OF MUSCLES.

Rupture of a muscle may occur without an external wound, and results from violent, irregular, or inco-ordinated contraction. An actual rupture of muscle is much less common than is rupture of a tendon ; it generally occurs in men, and is usually only partial. The muscle which ruptures may be quite healthy or it may have been the seat of disease or atrophy previously. Rupture of a healthy muscle generally results from some violent exertion, especially some sudden and unexpected movement, such as recovering the balance. The muscles which most commonly rupture in this way are the plantaris in playing tennis, the rectus femoris in recovering the balance, the pectoral or the deltoid in throwing, the biceps in pulling, the sacro-lumbalis in twisting the body rapidly, and the adductor longus in riders. The long muscles are most exposed to this injury, which generally occurs at or near the point of junction of the muscular fibres with the tendon ; the rupture may be either complete or partial. Effusion of blood occurs between the divided ends, and if the case be left alone, the ultimate result is the formation of a fibrous cicatrix between the torn ends with possibly some slight regeneration of muscular fibres. As time goes on, this cicatrix, which is broad and resisting at first, tends to stretch considerably, so that the patient never regains the full use of the muscle.

On the other hand, rupture is not uncommon in old persons, the muscles in the old taking part in the general atrophy of the body ; or again, the affected muscle may be the seat of waxy or fatty degeneration, such as occurs, for example, after typhoid or any other acute infective fever. The muscles most frequently affected after infected diseases are the rectus abdominis below the umbilicus, and the psoas ; in both cases rupture generally occurs when the patient sits up in bed too suddenly.

The symptoms accompanying this accident are sudden pain in the part, with a sensation of tearing, followed by loss of power in the affected muscle. There is a characteristic depression over the seat of rupture, and a swelling immediately above it, due to the retraction of the upper part of the muscle; the gap and the swelling above it become more pronounced when the muscle is voluntarily thrown into contraction.

TREATMENT.—**In Recent Cases.**—There are two methods at the disposal of the surgeon, viz., suture of the torn muscle fibres or an attempt to get healing without operation. The decision depends upon whether the rupture is complete or incomplete, whether the muscle is healthy or diseased, and also whether it is an important one. When an important healthy muscle is torn through almost completely and there is no contra-indication, the best treatment is immediate operation, which, however, should only be done by those who are sure of the asepsis of their wounds. If the wound become septic, very disastrous suppuration may occur, leading not only to permanent impairment of the limb from adhesions

of far greater severity than would have been the case had there been no operation, but even to loss of life. If, however, the surgeon has confidence in his power of securing asepsis, he is doing the best thing for his patient by suturing the muscle at once, and he will get a far better result by this means than by treating the case by position and relaxation of the muscle.

Operative.—A curved incision is made across the limb an inch or so above or below the seat of rupture, and the flap of skin and fascia thus marked out is turned aside. The convexity of the incision should run well beyond the actual line of rupture in the shorter portion of the muscle, so that the horns of the incision can be extended if much retraction of the other longer portion has taken place, and thus the torn ends can be completely exposed. A curved incision is preferable to a vertical or transverse one, not only because it gives better access to the parts, but also because the line of union in the muscle nowhere corresponds to the scar in the skin, and therefore adhesions between the scar and the rent in the muscle do not occur. The blood lying between the divided ends of the muscle comes into view as the deep fascia is divided and must be cleared out ; then the ends of the muscle are united by means of the suture just described (see Fig. 15), as many stitches being inserted as are required by the size of the muscle. Silk is better than catgut for the deep sutures, for here the wound is through unbroken skin, and is not expected to become septic ; the silk is stronger than catgut, and thus the patient may be allowed to move the limb rather sooner than if catgut were used. The union is completed by a fine continuous catgut suture. The deep fascia is then sutured separately and the wound closed.

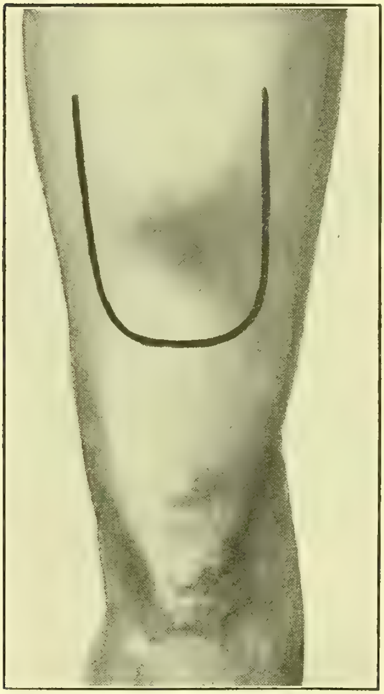


Fig. 16.—Line of Incision for Suture of a Ruptured Muscle. The shaded area denotes the depression corresponding to the gap between the divided ends.

After-treatment.—The limb should be put on a splint, with the muscle completely relaxed. In two or three days the latter is gradually put upon the stretch until, after a week or ten days, it is fully extended. The

splint should be left off in a fortnight and the patient allowed to move the limb to a limited extent ; this may be safely left to the patient himself, as he is sure not to do too much. Movement, however slight, is of advantage in preventing firm adhesions between the divided ends of the muscle and the surrounding tissues. In about five weeks the limb may be used actively, and then massage and passive movements may also be employed. The above description applies particularly to rupture of the quadriceps femoris muscle, but it is applicable to a rupture of any other muscle. In cases of rupture of a muscle of the upper extremity, such as the biceps, it is unnecessary to confine the patient to bed for more than a few days.

Non-operative.—This will be the line of treatment to follow when the patient himself objects to operation, when the muscle is only partially ruptured or is small and unimportant, when the rupture is only one of several serious injuries or when the surgeon does not deem it advisable to operate, either because he is afraid of suppuration or because he thinks the patient too old or too feeble. With regard to the last point, however, the operation is not as a rule accompanied by shock, and it is seldom that this would form in itself a sufficient reason for refusing operative treatment. In rupture of degenerated muscles, as after typhoid and other infective diseases, operation is not expedient, because the patient is not in a condition for operation, and also because the degenerated muscles might not unite satisfactorily.

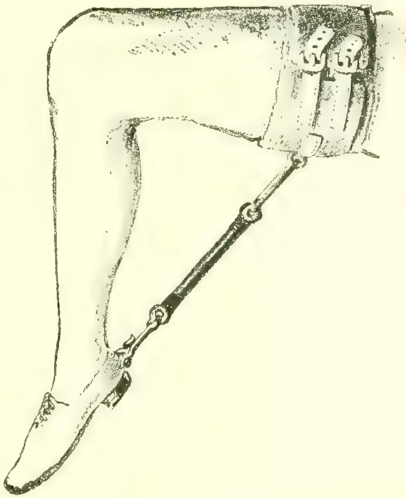


Fig. 17.—Apparatus for use after Rupture of the Calf Muscles. Should the thigh band tend to slip, as it often will from wasting of the muscles, it may be kept in position by fastening it to a band round the waist.

The part is put at rest, and the joint fixed in such a position that the muscles are relaxed as completely as possible, so as to allow the torn muscular fibres to come close together. For example, in the case of rupture of the *calf muscles*, the knee is flexed and the heel drawn up and fastened to the thigh ; this is usually done by means of a slipper which has an elastic band attached to the heel and fastened to a band around the middle of the thigh (see Fig. 17). This apparatus must be worn night and day for three or four weeks, in order to allow the union which is taking place to become fairly firm before it is subjected to stretching.

Later on, massage or electricity may be employed if there be any sign of adhesions.

In the case of rupture of the *quadriceps extensor femoris* the leg is placed on a back splint the foot of which is raised, so as to relax the muscle as far as possible. The skin of the thigh is shaved, and a large piece of adhesive plaster, cut as shown in Fig. 18 with the lower end left free at each side, is applied over the upper portion of the ruptured muscle, and bandaged to the limb. To each free end is attached a piece of elastic tubing, which is fastened to an upright on the bottom of the splint; as the elastic is tightened, the upper portion of the muscle is pulled down by the traction upon the skin. This method, however, is very imperfect,

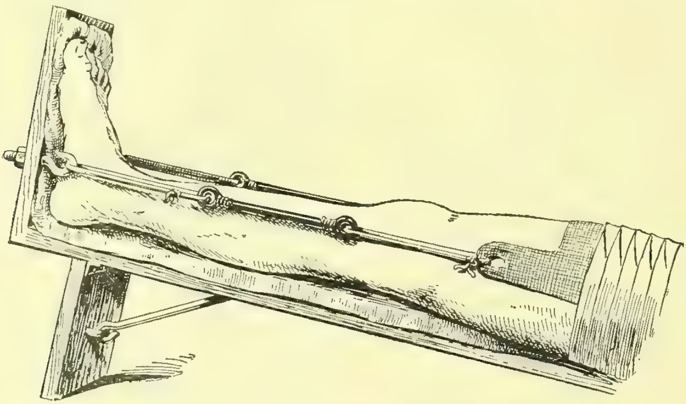


Fig. 18.—Treatment of Rupture of the Quadriceps Extensor Femoris by Position. The details are given in full in the text. For the sake of clearness the bandages securing the limb to the splint have been omitted.

as the actual pull upon the muscle is very slight indeed. The splint must be kept elevated for at least three weeks and is then gradually lowered until the limb is lying flat on the bed in four or five weeks. The patient should not be allowed to use the muscle until eight or ten weeks have elapsed since the injury. Subsequently, passive and active movements, massage, and electricity should be employed.

In rupture of the *rectus abdominis*, the divided ends are approximated as much as possible by diminishing the distance between the ensiform cartilage and the symphysis pubis by propping the thorax well up on a suitable bed-rest and pillows, and flexing the hip-joint by means of a large firm pillow placed beneath the knees. This pillow should be fastened to the head of the bed by a length of bandage on each side so as to prevent it from slipping, and it is well to have a firm foot-rest fixed to the bed-frame, so that the patient can brace himself against it.

In Long-standing Cases.—Cases may be met with in which rupture of a muscle has occurred some considerable time before the patient is seen, and the result may be great loss of power. Much good may often be

done by suturing the separated ends, even though a year or more may have elapsed since the rupture. We have operated with great benefit upon cases of rupture of the rectus femoris of long standing.

The operation is very similar to that just described. A curved incision, with the convexity downwards, is carried across the limb, well below the seat of rupture, the flap being turned up, the fascia divided, and the fibrous tissue between the divided ends exposed. This is cut away, and an attempt is made to bring the ends of the muscle together. In these long-standing cases it will be found that the divided upper end has curled up underneath, and become adherent to the posterior surface of the belly of the muscle at a little distance from the free end. If, therefore, the muscular fibres were divided where they apparently join the fibrous tissue between the two ends when the latter is being removed, a considerable portion of the length of the muscle would be lost. Hence, after dividing the fibrous tissue which connects the separated ends, the belly of the muscle should be turned up, and the spot where the actual division has occurred, should be looked for. The cicatrix at that part is then dissected out, and the muscular fibres unfolded. The stitches are passed in the manner already described (see p. 63); as they are tightened, the muscle is relaxed to its fullest extent.

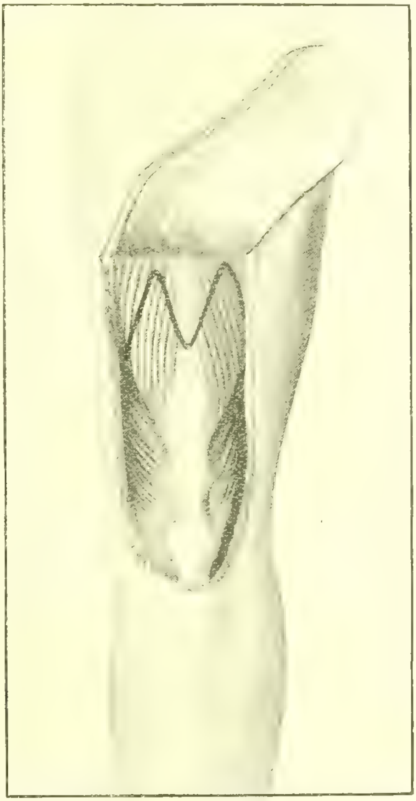


Fig. 19.—Method of Lengthening a Muscle. The lines of incision through the muscle are shown. The sides of the cones thus formed are stitched together, and their apices are united by the method shown in Fig. 15.

If it should be impossible to bring the ends of the muscle into apposition, in spite of full relaxation, it may be necessary to divide the muscle higher up in a zig-zag manner, so as to lengthen it. An incision is begun at one side of the proximal portion of the muscle, three or four inches above the rupture and carried through the muscle obliquely upwards for about two inches, then obliquely downwards to the original level, then upwards, and so on to the other side, until a zig-zag incision marking out a series of serrations or V's has been carried across the muscle. The

portion below this incision is then pulled down until only the apices of the serrations or V's on the two sides of the incision remain in contact; the adjacent sides of the serrations on each side of the gap are then stitched together, so that the muscular fibres terminate in blunt cones, alternately above and below the original zig-zag incision. The apices of these cones are then stitched together (see Fig. 19). In all these cases it is important to divide all adhesions between the muscle and the surrounding tissues at the time of the operation, as otherwise proper movement will not be obtained afterwards.

After-treatment.—The stretching of the muscle must be carried out more slowly and carefully than after a recent rupture, but usually the limb can be extended to its fullest extent after about six or eight weeks, and the splint can then be left off. The patient may be allowed to walk in about ten weeks after the operation.

ADHESION OF MUSCLES TO BONES.

The torn muscular fibres sometimes become united to the ends of the bone in fractures; sometimes the bones are displaced, and the muscle becomes adherent to them, although the muscular fibres are not markedly damaged. The result of this is that the subsequent action of the muscles may be greatly impeded and imperfect movement of the joint may result.

TREATMENT.—A good deal may be done to get rid of these adhesions by *massage* in the early stages of this condition; this is especially the case when the muscles have not been ruptured. When a muscle has been ruptured, however, or when a considerable time has elapsed before the patient comes under observation, it is usually necessary to have recourse to operative interference.

Operation.—A curved incision (see p. 66) is made, the fracture exposed, and the muscle carefully detached from the bone. If the ends of the bones be much displaced, it may be necessary to chisel away projecting portions, or to divide the union and bring the bones into proper position if there be considerable deformity. When there has been no rupture of the muscular fibres, the wound is closed, and massage is begun and full movements encouraged as soon as healing is complete. When, however, the muscle has been ruptured, and the ruptured ends have become adherent to the broken bones, the former must be detached carefully and all fibrous tissue cut away from between the divided ends, which are then united in the manner already described (see p. 63). Should this condition be recognised in recent fractures, early operation has the further advantage that the bones can be fixed in good position; this point is dealt with fully in connection with the treatment of Fractures.

HERNIA OF MUSCLES.

In this rare accident the fascia surrounding the muscle is torn, and the belly of the muscle protrudes through the opening, and becomes adherent to its edges. The affection is recognised by the presence of a soft lump in the course of the muscle, which moves when the muscle contracts ; the hole in the fascia can also be felt. The condition sometimes gives rise to pain and muscular disability ; in some cases the disability is so great that the patient is compelled to seek surgical advice.

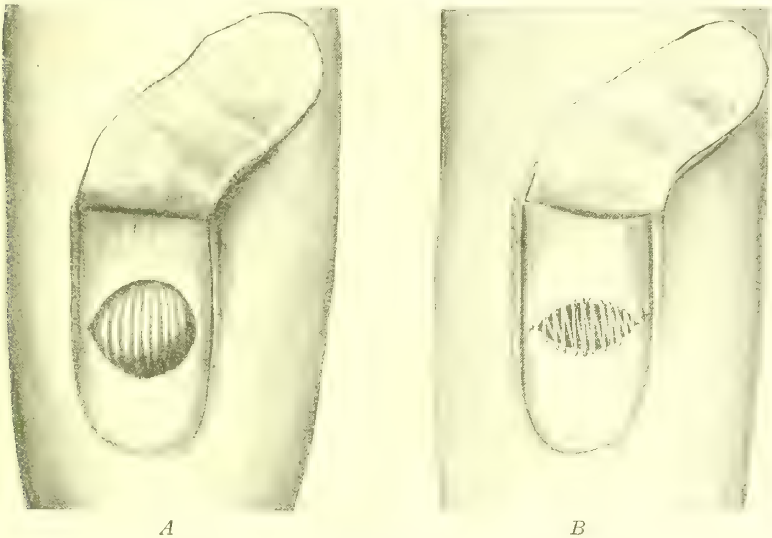


FIG. 20.—HERNIA OF MUSCLE. *A* shows the flap turned up, exposing the hole in the deep fascia and the protruding fibres. *B* shows the incision drawn together at its edges, the central part being closed by catgut sutures, introduced so as to form a grille.

TREATMENT. This will only be called for when there is pain or disability, and then the clear indication is to cut down upon and reduce the hernia of the muscle after separating the adhesions between it and the hole in the fascia, and to attempt to bring the torn margins of the fascia together. If the slit be vertical, the result is satisfactory ; when it is transverse, however, union is not so easily effected. A curved incision should be made over the herniated portion and a flap turned aside. The muscular fibres are defined, separated from the fascia and pushed back. If the fascia be sufficiently loose, an attempt should be made to close the opening in it. In any case it should be closed as far as possible with a continuous catgut suture, the strands of which crossing the space will probably be sufficient

to keep the muscle fibres in position until new connective tissue has formed (see Fig. 20).

Active movements should be practised within a day or two of the operation, and if necessary the faradaic current should be used in order to cause contraction of the muscle, and thus prevent it from adhering to the edge of the opening in the fascia.

INFLAMMATORY AFFECTIONS.

Myositis or inflammation of muscle may be either acute or chronic; the acute form may be circumscribed or diffuse, suppurative or non-suppurative.

ACUTE CIRCUMSCRIBED MYOSITIS.

This condition may be primary or secondary. As a primary affection it is usually met with in young males, and is generally attributed to over-work of the muscles or to cold. Most probably, however, it is either of traumatic or infective origin. When it occurs secondarily, it may be an extension from a wound, or may follow inflammation in the vicinity. Acute myositis may be either hyperplastic or suppurative.

ACUTE HYPERPLASTIC MYOSITIS.—In the hyperplastic form, which is much the more common, the muscle becomes hard and friable, the fibres gradually disappearing and fibrous tissue taking their place; the final result of the condition is sclerosis of the muscle. The affection often occurs in the neighbourhood of suppurative inflammations, for example, near glandular abscesses.

Treatment.—The first point in the treatment of the hyperplastic form is to remove the cause, if possible. When the affection is secondary to an abscess or inflammation in the vicinity, the abscess or the inflammatory condition should be treated appropriately. When there is a primary non-suppurative myositis and a rheumatic condition is suspected, 10-grain doses of salicylate of soda may be administered every four hours. At the same time hot fomentations or india-rubber hot-water bottles, applied over the part, will usually relieve the pain; it may, however, be acute enough to call for the administration of morphine. When the acuter symptoms have passed off, and the patient can bear it, massage should be employed in order to get rid of the exuded material quickly and so avoid sclerosis of the muscle.

ACUTE SUPPURATIVE MYOSITIS.—The suppurative form is rarely a primary condition; it is usually due to extension of suppuration from the neighbourhood. Multiple abscesses in muscles generally occur as a result of pyæmia or glanders; diffuse suppurative myositis—a condition corresponding to diffuse cellulitis—generally arises in connection with a septic wound.

Apart from pyæmia, or suppuration in glands or bone the affection

occurs idiopathically in certain muscles, the most common being the psoas. This condition is rare, and the reason why the inflammation should locate itself in a certain muscle, is obscure; this affection is certainly due to the presence of the pneumococcus in some cases.

Treatment.—Free incision and drainage of the cavity, similar to that already described for acute abscess, is the only satisfactory method (see Vol. I. p. 27).

CHRONIC MYOSITIS.

This is a serious condition, because it leads to great impairment of the function of the muscle, and also because it is very difficult to arrest. It occurs in the sclerosing and the ossifying forms.

SCLEROSING MYOSITIS.—The muscles gradually become converted into fibrous tissue, which contracts and leads to permanent shortening; the entire muscle may not be affected, but movement is necessarily materially interfered with by the fibrous bands. The condition may follow acute suppurative or non-suppurative myositis; it also occurs in muscles around inflammatory foci of long standing, such as suppurating joints, or where hydatid cysts, gummata, foreign bodies, etc., are present in the muscle. It is also supposed to occur as the result of rheumatism. It leads to shortening and imperfect action of the muscles, and various deformities.

Treatment.—It is necessary, first, to ascertain and remove the cause of the disease, if possible; then an attempt should be made to arrest the inflammatory process and prevent subsequent contraction. The **general** treatment is usually ineffectual; when there is no syphilis it should be directed against any rheumatic or gouty tendency that may possibly be present. The administration of mercury is sometimes of service. The important point in the **local** treatment is to fix the part in such a position that the muscle is put as much upon the stretch as the patient can bear; counter-irritants and massage should then be applied to the affected area. Progressive contraction of the muscle must be combated by means of splints, extension apparatus, etc. This is very difficult, for the contraction leads to such pressure that the apparatus must be altered from time to time and thus the contraction is apt to increase. After the inflammation has subsided, however, matters may be improved by dividing either the tense bands in the muscle itself, or its tendon. In order to divide the fibrous bands which run in the muscle, it is best to make a free incision down on to the latter in order to see the exact condition of affairs; if a large muscle be affected, it is well to turn aside a flap of suitable size. Everything that appears to be infiltrated or fibrous can then be divided, and the healthy muscular bundles are left intact. The various incisions should be made at different levels. In extensive cases, however, it is better to divide the tendon instead of the muscle, because satisfactory union is more likely to take place in tendon

than in muscle. After the muscle or tendon has been divided, suitable apparatus is applied to maintain the position and to prevent subsequent contraction.

OSSIFYING MYOSITIS.—This occurs either as an affection limited to one muscle or group of muscles, or as an ossification of the entire muscular system.

The localised form may be seen in the neighbourhood of fractures, where spicules of bone radiate from the fracture into the muscles which are attached in its neighbourhood ; the ossification usually commences in the tendons and extends thence into the muscle ; it may also follow injury apart from fracture, *e.g.* a severe blow. A similar condition also occurs around joints which are the seat of rheumatoid arthritis. Apart from these conditions, however, ossification is sometimes met with in the bellies of muscles. The most common seat is in the adductor longus, and the name given to this condition is 'rider's bone.' Here ossification occurs in the substance of the muscle, and may extend through it from end to end, rendering it entirely rigid, and interfering considerably with the movement of the limb. Among other muscles which may be affected are the deltoid or the biceps cubiti in soldiers as a result of musketry drill.

The pathology of the condition is not clear. Some look on it as due at first to a hæmatoma in the muscle, followed by partial absorption of the blood, and a deposit of calcareous salts in the remainder, but in many cases true bone is actually formed.

Treatment.—When the condition is limited to a single important muscle and when much disability results, the new bone should be excised. This may involve the loss of the entire muscle, but this actually benefits the patient by allowing the others to act freely once more. When the entire muscle is not involved, it is only necessary to remove the ossified portion ; if sufficient healthy muscle be left, the divided ends may be re-united. Sometimes, however, the process stops and the bone becomes absorbed. Hence, when an unimportant muscle is affected, and there is not much disability, it may be better to immobilise the limb and to watch the result by means of repeated skiagrams. The condition is apt to recur after operation, especially when the operation is limited to a mere shelling out of the bone ; a layer of muscle around the bone should always be removed as well.

The generalised form of ossifying myositis is not common; it usually begins in children, especially in males. It is probably a neuropathic disorder resembling pseudo-hypertrophic paralysis, and it probably affects the connective tissue of the muscle. It generally begins in the muscles about the spine, more especially the latissimus dorsi, erector spinæ, and also the pectoralis major. Whether the affection is a true inflammation or not is a matter of doubt.

Treatment.—Unfortunately nothing is known that will arrest the

condition, which progresses in spite of treatment, affecting whole groups of muscles, and sometimes ultimately the entire muscular system, so that the patient finally dies from exhaustion or from repeated bronchitis and broncho-pneumonia.

TUBERCULOSIS.

Tuberculosis of muscles is usually secondary to tuberculosis in the vicinity: for example, tuberculous ulcers on the tongue may lead to tuberculous disease in its muscles; tuberculous abscesses in the neck often perforate the sterno-mastoid and set up tuberculosis there. In psoas abscess, which is a tuberculous abscess extending down the sheath or in the substance of the psoas muscle, the psoas may be more or less completely destroyed by the tuberculous process.

The treatment of tuberculosis of muscles is the same as that of local tuberculosis in other tissues; namely, excision if possible, or, if not, scraping and general treatment (see Vol. I. p. 231).

SYPHILIS.

Syphilis of muscle may be met with in both the secondary and tertiary stages. In **secondary** syphilis, generalised muscular pains are not uncommon, as, for example, syphilitic lumbago, or syphilitic inflammation of the occipito-frontalis, giving rise to severe headache. The pain is often nocturnal, is increased on pressure, and is intermittent. These conditions yield readily to the treatment appropriate for secondary syphilis (see Vol. I. Chap. XI.).

Tertiary lesions consist essentially of gummata in the muscles which may be followed by sclerosis. The muscles of the tongue and the masseters are those most often affected. Gummata are also met with in the intermuscular connective tissues or the fascial sheaths, *e.g.* of the muscles of the leg, or the sterno-mastoid near its origin. The *treatment* is similar to that of gummata in other situations (see Vol. I. Chap. XI.). If much sclerosis ensues, it must be dealt with on the lines laid down for the treatment of the similar condition resulting from chronic myositis (see p. 73).

In **congenital** syphilis a painful mass is often found in the sterno-mastoid muscle during the first few months of life. Sometimes these are simple hæmatomata occurring during birth, but sometimes, undoubtedly, they are tertiary gummatous lesions, and yield readily to mercurial inunction, which is best done over the sterno-mastoid itself. At the same time the general treatment of syphilis must be employed (see Vol. I. Chap. XI.).

HYDATID CYSTS.

Hydatid cysts are not uncommon ; something like 2 per cent. of all cases occur in the muscles. Those most frequently affected are the adductors of the thigh, the trunk muscles (especially those of the lumbar region), and the pectorals. The cyst is usually embedded in the substance of the muscle, and the muscular substance around it becomes thinned, degenerated, and fibrous.

The cysts should be opened and the whole cyst wall shelled out. It is not necessary to take away the fibrous wall surrounding the true cyst wall, provided that the latter, which lies within the fibrous capsule, be peeled off. If this be impossible, the cyst must be opened freely and drained, and it is well also to scrape the wall.

NEW GROWTHS.

Like new growths elsewhere, tumours affecting muscles may be primary or secondary.

Primary tumours of muscle are rare. The most common are the **cavernous angiomata** which occur about the masseter, the muscles of the cheek, etc. They are characterised by the presence of an enlargement of the muscle of a soft character, which increases on coughing or crying, and which disappears almost entirely when pressure is made upon it ; it re-appears immediately the pressure is left off. The *treatment* for tumours of this character is electrolysis (see Vol. I. p. 256).

Of other primary neoplasms, **lipomata** occur within the muscular sheaths, **myxomata** are met with, and sometimes also **sarcomata.**

Secondary tumours of muscle are more common than primary ones. They attack the muscles by direct extension, as in cases of epithelioma of the lip or tongue, cancer of the breast, stomach, etc., or they may result from metastasis.

The **treatment** is excision, the extent of the operation depending on the nature of the tumour. For example, a lipoma may be shelled out of its sheath, while a sarcoma or carcinoma must be removed along with a considerable portion of the muscle around.

CHAPTER VIII.

AFFECTIONS OF TENDON SHEATHS.

INFLAMMATORY AFFECTIONS.

THE most important diseases of the tendon sheaths are the inflammatory conditions grouped together under the term teno-synovitis.

ACUTE TENO-SYNOVITIS.

A suppurative and an acute non-suppurative teno-synovitis are met with, and the latter may be of the dry or the serous form. The dry form may be further divided into two groups, namely, the dry crepitating teno-synovitis and the plastic teno-synovitis.

DRY CREPITATING TENO-SYNOVITIS manifests itself chiefly by crepitation on manipulation. Pain on movement is complained of ; there may also be pain on pressure and some diminution in the freedom of the muscular movements. Sometimes there is slight swelling along the course of the tendon ; often there is none. When the muscle contracts, a characteristic soft rubbing sensation is felt, very similar to that experienced when two pieces of silk are rubbed over one another ; this crepitation commences on the second or third day of the affection. The disease usually disappears spontaneously in from ten to fifteen days, but it is very prone to recur. Adhesion of the tendon to its sheath, and consequently impaired movement, may occur unless suitable treatment be adopted early.

The condition may result from over-use of the tendon, as, for example, in washerwomen, in whom it occurs about the back of the wrist, the tendon sheaths chiefly affected being those of the thumb and the radial extensor tendons. It also occurs in the sheaths of the extensor tendons in pianists. It is sometimes met with in the lower extremity after prolonged skating or bicycling, when it usually affects the tibials, the long extensors of the toes, or sometimes the peronei. It may occur in the tendo Achillis sheath in soldiers as a result of over-marching. Rheumatism

is supposed to be a predisposing cause, and many attribute the prevalence of the affection in washerwomen to the fact that the hands are repeatedly alternately plunged into warm water and exposed to cold air rather than to excessive use.

Treatment.—*Rest* to the affected limb for a week or two is usually advisable ; it must not be continued longer than this, lest adhesions form and interfere with movement. In the case of the hand, the forearm and hand should be placed on an anterior splint, reaching almost as low as the knuckles, and should be carried in a sling ; the thumb should be allowed to hang down by the edge of the splint, and the metacarpus should be thrown well back. *Blisters* are often of considerable value ; an elongated blister (see Vol. I. p. 19) should be applied over the region of crepitation, and this may be repeated in three or four days ; generally two applications are sufficient When the blister has risen, it should be punctured, the fluid allowed to escape, and boric ointment applied, while outside this *light compression* may be applied by means of a mass of wool bandaged on moderately firmly until the blister has quite healed. When this has occurred, benefit may be obtained by rubbing unguentum hydrargyri or unguentum hydrargyri oxidi rubri into the part night and morning for two or three days. When the splint is left off, the patient is encouraged to move the fingers and wrist, and *passive movement* should be employed if there be any stiffness. The three essential points in the treatment during the active stage are—rest, blistering, and light compression, followed by early movement. If there be a rheumatic tendency, salicylate of soda (gr. v–x) should be given three times a day.

PLASTIC TENO-SYNOVITIS.—This form of the affection is much more serious than the one just described ; the effusion is greater and the tendency to the formation of adhesions is much more marked. In it a quantity of fibrinous material is thrown out on the inner surface of the sheath, and this afterwards organises and give rises to adhesions between the tendon and its sheath, whereby movement may be seriously impeded. The origin of this condition is generally traumatic ; it follows contusions, fractures about the joints, sprains, or dislocations, or it occurs after wounds and suppurations in the vicinity of the tendon sheaths. It may also, however, occur without any previous injury, when it is supposed to be of rheumatic or gouty origin. The plastic form is the one so common after diffuse cellulitis of the hand, whitlow, and similar affections, and here the inflammation of the tendon sheaths is secondary to the other conditions, and is not necessarily due to pyogenic organisms. It occurs as a complication of gonorrhœa, sometimes alone, sometimes as an accompaniment of gonnorrhœal arthritis of a neighbouring joint.

Pain, especially on movement or pressure, is very acute, but crepitation is not marked. From an early stage there is interference with the free movements of the tendons in their sheaths ; even when the disease has lasted only two or three days it may be found that numerous soft

adhesions give way on attempting to move the fingers when very slight force is employed. These adhesions soon become organised, and increased force is required to break them down, while the power of spontaneous movement is lost.

Treatment.—Great patience and endurance are required from both the patient and the surgeon, while the ultimate result is rarely quite satisfactory. From the earliest stage care must be taken to prevent the formation of adhesions, and to put the limb in such a position that, if adhesions do form, they can be readily broken down. For example, when the flexor tendons of the hand are affected, the hand must be in a condition of semi-flexion, because if the fingers be kept extended on a splint, passive movement of the fingers would not break down the adhesions. In dealing with the hand, the best plan is to keep it in a sling (or to lay it on a pillow with the metacarpus thrown well back, if the patient be confined to bed) and to leave the position of the fingers to nature; they will be found to assume a position of semi-flexion. During the acute stage warm *fomentations* should be applied. In gonorrhœal cases, a gonococcal vaccine should be given (see Appendix, Vol. I. p. 517).

Important as rest is in acute inflammatory conditions, it must not be persevered with too long in these cases. At the end of a week at latest, *passive movement* of the fingers should be practised at least once a day, so as to break up any adhesions in process of formation; the patient should also be encouraged to move the fingers for himself. Unfortunately both active and passive motion cause intense pain, but despite this they must be vigorously persevered with. As soon as the acuteness of the inflammation has passed off (as evidenced by the disappearance of tenderness on pressure), *massage* should be employed to promote absorption of the plastic material, while both passive and active movements should be continued. At this stage the patient can do a great deal for himself by moving the affected fingers to their fullest extent with the unaffected hand, and by trying to carry out active movement. The surgeon himself should also move the fingers freely in all directions once a day, and in this way the formation of adhesions can generally be kept under to a very large extent. Super-heated air or radiant heat baths to the part are also very valuable just before the movements are carried out.

When the patient is seen at a later period, and firm adhesions have already formed, they should be broken down under nitrous oxide once or even twice a week, if the procedure does not produce very marked reaction; in the interval, hot-air baths, massage, passive movement, and faradism should be employed daily. In this way, a fairly satisfactory result may be obtained in some cases if the adhesions are not numerous. In the majority of cases, however, only a certain amount of improvement will result. *Fibrolysin* has been used in these cases, but we have seen no definite advantage in its use.

ACUTE SEROUS TENO-SYNOVITIS may follow the dry form, or may be synovitis with effusion from the first. It is, perhaps, most commonly met with in rheumatism, and more especially affects the extensors of the fingers, the long flexor of the thumb, the peronei, and the tibial tendons.

The disease is characterised, as a rule, by pain, by interference with movement, and by redness and œdema of the skin. It usually gets well, but, as the fluid becomes absorbed, there is a tendency to the formation of adhesions, although not to the same extent as in the plastic form.

Treatment.—The treatment is similar to that of the acute plastic form. As the fluid becomes absorbed and the acute stage passes off, compression by means of a mass of cotton wool (see Vol. I. p. 22) should be used, after which active and passive *movement* of the fingers must be employed and *massage* carefully carried out. It is necessary to be careful with massage, because if it be too vigorous, it may lead to a recurrence of the trouble.

SUPPURATIVE TENO-SYNOVITIS.—This condition is usually traumatic, following wounds involving tendon sheaths, or tenotomies that have become septic. It may also occur in scarlet fever, pyæmia, etc., but it is most often secondary to inflammation of the surrounding parts, as in the case of a whitlow, especially one affecting the thumb or the little finger, where there is direct extension of the septic material along the sheath of the tendon. In these cases the inflammation is usually very violent, and suppuration occurs early. When the condition is very acute the tendon generally sloughs, while in less acute cases the tendon sheath and the tendon itself become covered with granulations, which subsequently lead to the formation of firm adhesions. After a time the sheath gives way, an abscess forms outside it, and the inflammation may spread to neighbouring bones or joints.

Treatment.—The sooner the tendon sheath is laid freely open the better; in fact, in the very acute form *early incision* offers the only chance of preserving the tendon. If the opening of the abscess be delayed the tendon will certainly slough, and irretrievable damage will result; as soon, therefore, as the condition is recognised, free incisions should be made into the tendon sheath, the pus washed out with sterile saline solution, and a drainage tube introduced. The free exit of the pus is so important that the surgeon should not hesitate to lay the sheath very freely open. Hot baths, in which the liquid is frequently changed and the temperature maintained at 100° to 105° F., are very useful in the after-treatment; they should be employed for several hours daily, but care must be taken that the parts do not become sodden. Passive congestion by means of Bier's method (see Vol. I. p. 13) may also be employed.

When the tendon sloughs, the part is irretrievably damaged. When death of the whole tendon occurs right up to the muscle, the separation is

more rapid than when only a portion sloughs ; in the latter case it may be months before the dead part is got rid of, and as the tendon can be of no use subsequently, convalescence may be materially shortened by cutting it away as soon as the surgeon is sure that it has necrosed, as will be indicated by its ragged and greyish appearance ; if a little too much be taken away, no particular harm is done. When the tendon of a finger sloughs it will often save time if amputation be performed early.

When sloughing does not occur, *active and passive movement* should be begun as soon as the wound begins to heal, and should be persevered with daily ; it is not necessary to wait until the wound has healed before commencing it. In these cases the tendency to adhesion is greater than in the plastic form, and the resulting adhesions are firmer, and much patience and self-denial must be exercised by the patient if a satisfactory result is to be obtained. Abandoning passive movement prematurely will certainly result in permanent uselessness of the part.

During the acute stage the patient suffers from severe inflammatory fever, and the appropriate treatment must be employed (see Vol. I. Chap. I.). When the upper extremity is affected, the patient need not be confined to bed after the acute inflammatory symptoms have subsided.

CHRONIC TENO-SYNOVITIS.

This affection is generally serous, and may follow on the acute form, or it may occur as the result of rheumatism or of excessive use, as, for example, in various trades. Chronic serous teno-synovitis is most often seen in the hand, where it chiefly affects the common palmar sheath ; it also occurs in connection with the popliteus and certain other muscles.

The tendon sheath becomes slowly distended with serous fluid, without any marked pain or interference with movement at first, and the patient may only become conscious of the trouble when the distension has become considerable. In the case of effusion into the common palmar sheath a swelling forms in the palm, and the fluid extends beneath the annular ligament into the forearm, where it forms a second swelling, and fluctuation between the two can generally be obtained. The fluid is limpid and straw-coloured, and the tendon sheath is smooth and not materially thickened.

A second form, however, occurs, probably in connection with rheumatism, in which the tendon sheath becomes much thickened and covered with villous outgrowths. This condition resembles that sometimes found in joints in which the synovial fringes have become hypertrophied, a condition known as 'lipoma arborescens.' In these cases the chances of getting a good result without an extensive operation are comparatively slight. Many cases of chronic teno-synovitis are, however, tuberculous in nature ; in them the fluid is scanty and turbid, and often contains rice-like bodies, and there is thickening of the sheath. These changes are

accompanied by much more pain and stiffness, less marked fluctuation, a tendency to the formation of abscesses, and other signs of tuberculosis. We shall describe this affection separately.

TREATMENT.—**Of Simple Chronic Teno-synovitis.**—When the fluid is limpid and the wall of the sheath is not thickened, the best treatment is to *open and drain the sac antiseptically.* In the case of the palmar bursa, an incision is made into the sac above the annular ligament, and a drainage tube is introduced and pushed beneath the ligament into the palm; in simple teno-synovitis it is not necessary to make an opening in the palm as well. An operation of this kind must be done with full antiseptic precautions; otherwise it should not be adopted, for tendon sheaths are very liable to septic inflammation of an exceedingly dangerous character, leading not only to sloughing of the tendon and abscesses along its sheath, but often to general septic poisoning.

The drainage tube may be removed in about fourteen days as a rule, but, if there be several drops of fluid from the tube in the course of twenty-four hours and the dressing be stained over an area the size of a two-shilling piece or more, the drainage should be continued. As soon as the stain on the dressing does not exceed the size of the orifice of the drainage tube, and does not extend deeply through the layers of the dressing, the tube may be left out.

While drainage is being carried out, the arm should be supported in a sling; a splint is not usually necessary. A large dressing is applied and made to fill up the whole hollow of the hand, so that the dressing alone keeps the limb at rest. The fingers should be left free for active movements after ten days, and should be moved passively at intervals, whether drainage is being continued or not. If there be no adhesions, the patient may move them himself, but if adhesions have formed, they should be broken down, if necessary under a general anæsthetic, every three days at first and more frequently later on. After the drainage tube has been removed, the small incision will heal in a few days, and, as a rule, there will be no recurrence of the effusion.

When this method is deemed inadvisable, or when the patient objects to an incision, the next best method of treatment is to *puncture the sac,* withdraw the fluid, *and inject an irritant.* The aspirating needle or trochar and canula must be boiled for 20 minutes, and the syringe must also be disinfected. The canula is inserted into the sac above the wrist, most of the fluid drawn off, and 20 minims of undiluted carbolic acid injected. It is not desirable to set up too much inflammation, as otherwise adhesions might form. The hand should be kept at rest on a splint for about ten days, fomentations being applied if there is much swelling or pain. Afterwards massage and movement should be employed as in the other cases.

Of Villous Teno-synovitis.—In the villous form of chronic teno-synovitis, nothing short of excision of the tendon sheath will arrest the effusion. Removal of the fluid by a canula and injection of carbolic

acid may be resorted to as a preliminary measure. In some cases the villous projections become adherent to the wall, and the surface loses its roughness to a considerable extent; but in most cases *excision* must be employed. In the case of the wrist this operation is difficult. A free vertical

FIG. 21.—INCISION FOR REMOVAL OF A COMPOUND PALMAR GANGLION. This is also the the incision for the radical cure of villous teno-synovitis of the flexor tendons.

median incision should be made from the lower third of the forearm to the middle of the palm, the annular ligament divided, and the common flexor sheath carefully defined and clipped away wherever it shows the villous condition. The annular ligament is then united with catgut and the wound closed, a drainage tube being used for some days. Massage and movement are required when the wound has nearly healed.

TUBERCULOUS TENO-SYNOVITIS.

This affection is met with in two forms; in the one, the tendon sheath is greatly distended and filled with loose bodies, the so-called 'rice-bodies,' and in the other the chief change is thickening of the tendon sheath without much effusion into the cavity, a condition corresponding to the thickening of the synovial membrane of tuberculous joints.

TENO-SYNOVITIS WITH 'RICE BODIES.'—The form in which the synovial sheath is distended, and filled with rice-like bodies.

was at one time looked upon as a simple chronic teno-synovitis, but it is now known to be tuberculous in nature. In this affection there is also a small quantity of turbid fluid and the sheath is thickened and irregular, with fibrinous or cheesy material and 'rice bodies' adherent to its inner surface. The latter vary in size from the head of a pin to a pea; they are smooth, flattened, and usually ovoid. The condition may coexist with disease of a neighbouring joint, but it more often occurs alone. The most usual situation for the affection is in the common flexor sheath in front of the wrist, where it forms the so-called 'compound palmar ganglion'; it may also occur on the front of the fingers, the back of the wrist, or in the sheath of the peronei tendons and the extensors of the foot. Active work seems to predispose to the condition.

The most noticeable signs of this condition are the rubbing of these bodies against each other, some dull pain increased by pressure, and an indistinct sense of fluctuation. The presence of the 'rice bodies' is very noticeable when there is a constriction in the sac, as there is, for example, on the palmar surface of the fingers, where one part of the distended sheath is in front of the phalanx, and the other part is in front of the metacarpal bone. On pressing the contents from one part into the other the crepitant feeling of the 'rice bodies' as they pass through the constricted portion is quite evident; this is also well marked in the case of the compound ganglion in front of the wrist.

The *prognosis* is grave. The disease is apt to extend from the sheath to the tendons themselves and destroy them, and, apart from local troubles such as adhesion and suppuration, it is likely to become general or to extend to neighbouring bones or joints.

Treatment.—The best method of treatment is to make a *free incision* into the tendon sheath, and to evacuate all the 'rice bodies.' The cavity should then be scraped with a sharp spoon, and washed out with a 1 in 4000 sublimate solution, and filled up with a 10 per cent. emulsion of iodoform and glycerine (see Vol. I. p. 234). The skin is united by a continuous suture; no drainage tube is required. In the case of compound ganglion of the wrist extending into the forearm, two incisions should be made, one above and one below the annular ligament. The contents of the sac should then be evacuated, the cavity filled up with iodoform and glycerine and the skin wound stitched up. The hand should be kept on a splint for several weeks, passive and active movements being carried out once or twice a week, and later once or twice daily.

When this method does not succeed, the sheath must be dissected out as completely as possible in the manner described below. Other methods, such as compression or injection, are of little value; the same may be said of draining a compound palmar ganglion after splitting the annular ligament.

TENO-SYNOVITIS WITHOUT 'RICE BODIES.'—In the second form of tuberculous teno-synovitis the synovial membrane is

much thickened and pulpy, and this condition is often secondary to disease of bones or joints in the neighbourhood, or to chronic abscesses, though sometimes it is primary affection.

The patients are usually from 18 to 25 years of age, and the tendon sheaths chiefly affected are those about the hand and instep. The disease generally begins in the sheath, and may be confined to it for a considerable time, but the tendon often becomes affected eventually, and may ultimately be eaten through completely by the granulation tissue. Abscesses frequently form, make their way to the skin and burst ; in other cases the disease may extend to the joint over which the tendon passes.

The condition may follow upon some previous inflammation, or may come on insidiously, and in the latter case the first thing that the patient usually notices is difficulty in movement and the presence of a diffuse, ill-defined, soft swelling parallel to the tendon ; in some situations, as for example, at the front of the wrist, this swelling may be hour-glass in shape, one portion of the swelling being situated in the palm below the annular ligament, and the other portion in the forearm immediately above this structure. The mass is elastic and semi-fluctuating and is movable laterally along with the tendon, but not longitudinally. The movements of the tendons are impeded, and later on there will be contraction or even solution of continuity of the tendons.

Treatment.—Operative.—*Excision* of the affected sheath or sheaths is the best treatment. An extensive operation is usually required, as the treatment must be as thorough as in the case of an arthrectomy for

Fig. 22.—Fine Dissector. One end is a very fine dissector with which delicate work, such as the separation of the tendon sheath from the surrounding parts, can be easily done ; the other is bent and is probe pointed and serves to pull aside the structures thus isolated.

tuberculous joint disease. The incisions must be so planned that the sheath or sheaths are fully exposed over the whole of the affected area. In the case of the extensor tendons for instance, a flap with its convexity to one side is raised from the back of the hand so as to expose the whole swelling. The tendon sheath is then carefully isolated from the surrounding parts, and the whole of the disease is cut away with scissors or the knife. This is usually comparatively easy ; the chief essential for success is to isolate the whole of the affected area from the healthy tissue before opening and clipping the sheath away. The tendon sheath is isolated with a blunt dissector or a gland separator (see Fig. 22), and the deeper part freed so that it can be lifted up from the subjacent tissues. The sheath is then divided by two circular incisions, one well above and the other well below the limits of the disease, and the affected portion is incised vertically from one circular incision to the other ; this lays the

sheath fully open, and the whole of the diseased portion of the sheath can then be removed in one piece (see Fig. 23). After removal of the sheath, the tendon should be examined to see whether it is affected; if any soft points be found, they should be thoroughly scraped. The skin flap is then sutured, and the hand is placed on a splint with the fingers somewhat flexed and kept at rest until the wound has healed. When the affection is situated in the palmar bursa, the operation is performed in a similar manner, the annular ligament being split as already described on p. 83, and the tendon sheath dissected out.

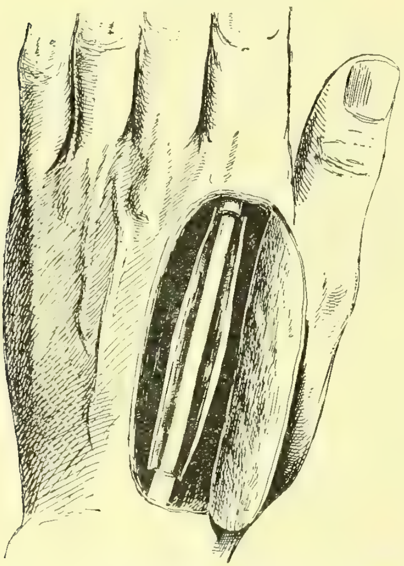


FIG. 23.—METHOD OF EXCISION OF A TENDON SHEATH. A flap is thrown back, and after the sheath has been isolated from the surrounding structures, it is divided circularly well beyond the limits of the disease. A longitudinal incision joining the two circular ones then allows the whole of the affected portion to be removed as a flat ribbon-like mass.

After-treatment. — The first dressings may be removed and the stitches taken out in ten days, when a collodion dressing is fixed on, the splint left off, and the patient encouraged to practise active movements; passive motion is employed once or twice a week for several weeks.

We have treated several cases of this kind, and have been very much surprised at the ease with which movement is regained. There is not nearly the same difficulty in obtaining free movement, nor is there the same tendency to adhesion to surrounding parts as there is in cases of plastic teno-synovitis in which the tendon sheath is intact; indeed it has occurred to us that removal of the sheath might be the best practice in cases of plastic teno-synovitis limited to a few tendons. The tendon moves freely in the cellular tissue, and a sort of sheath is soon reformed around it. If recurrence of the tuberculous affection take place, the operation should be repeated; as a rule the recurrence is at the upper or lower end of the incision, and is due to an insufficient amount of the sheath having been removed at the first operation.

Short of excision the next best plan is to *scrape* away the bulk of the tuberculous material, and to inject iodoform and glycerine emulsion. If it be undesirable to give an anæsthetic for the purpose, an exploring needle may be introduced into the cavity, any fluid that is present drawn off, and the emulsion injected without withdrawing the needle. In these

cases after operation it is well to use *tuberculin injections* (see Vol. I. p. 522).

The non-operative methods of treatment, which may have to be employed in some cases, are very unsatisfactory. *Fixation* of the part on a suitable splint for a prolonged period is essential. Simultaneously, *firm pressure* should be applied by means of a mass of cotton wool wrapped around the limb with a bandage stiffened with gum or starch outside it. In the case of the hand, for example, the limb is fixed on a splint with the fingers in a semi-flexed position, the metacarpus extended, and the thumb hanging down over the side of the splint, and not applied closely to the forefinger ; this position is adopted because, should stiffness occur, the power of opposition of the thumb to the

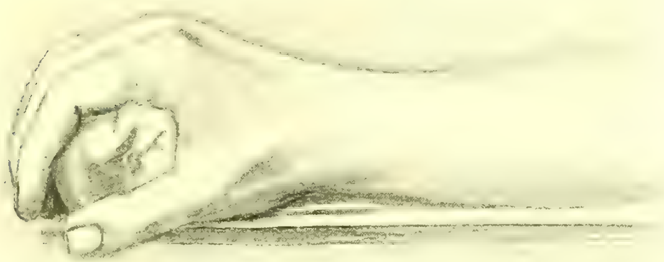


FIG. 24.—METHOD OF APPLYING A SPLINT TO THE HAND AND FOREARM IN TENO-SYNOVITIS. To show the position that the thumb should be made to assume.

fingers would not be lost. The starch and cotton wool bandage is then firmly applied. Bier's treatment by passive congestion (see Vol. I. p. 13) may be tried in these cases. If used in combination with the treatment by pressure, the cotton wool should be applied by means of an ordinary cotton or elastic bandage, as it would need to be removed daily.

The patient should be placed under the best hygienic conditions obtainable ; if possible he should be sent to the country, and cod-liver oil and a plentiful nourishing diet should be administered. The results, however, are usually very unsatisfactory, and unless some radical treatment be employed, the condition is likely to become complicated with disease of a neighbouring joint.

When a case of this kind is complicated with joint or bone disease, the chances of eradicating the mischief, by either expectant or operative treatment are comparatively small. Expectant treatment is certain

to lead to disappointment, whilst conservative operative treatment will generally require to be too extensive to be feasible. When both the joint and the tendon sheaths lying over it are diseased, it would be necessary not only to dissect away the tendon sheath, as already described, but also to perform arthrectomy of the joint. Between the two, the chances of eradicating the disease on the one hand, and of obtaining a useful limb on the other, are very remote. An operation of this nature will also of necessity be a prolonged one, and the patient will be exposed to the danger of severe shock. When there is no special urgency, these cases should be treated with splints and *tuberculin*, etc., but if this fails, operation must be considered. In most cases *amputation* is the best practice when tuberculous disease of a joint coexists with a similar disease in the tendon sheaths over it. It is only when the joint disease is in quite an early stage and when the tendons involved are few in number, that it is justifiable to limit operative interference to dissecting out the tendon sheaths and fixing the joint. But when the disease is extensive, and especially when abscesses have formed in connection with either the sheaths or the joint, some radical operation such as amputation is necessary. Further, there seems to be a special liability to the occurrence of phthisis in these cases of tendon sheath disease, and unless something radical be done, the patient is very apt to develop lung trouble.

SYPHILITIC TENO-SYNOVITIS.

Syphilis affects the sheaths of tendons in the same way as it attacks the synovial membrane of joints. In the *secondary period* of the disease the tendon sheaths, especially in the neighbourhood of the joints, may be affected with a form of serous synovitis. The condition is chronic, but it yields readily to anti-syphilitic treatment (see Vol. I. Chap. XI.). In the *tertiary stage* gummata may form in connection with the tendon sheaths, but they are very rare. The treatment is that appropriate for tertiary syphilis.

NEW GROWTHS.

New growths in connection with the tendons and tendon sheaths are very rare. Myxoma, fibroma, and sarcoma may occur as primary growths: their treatment is removal according to the circumstances of the case.

GANGLION.

By this term is understood a sac attached to a tendon sheath, containing a glairy fluid; the sac wall resembles in structure the tendon sheath. Ganglia generally occur in connection with tendons that are overused; they are common on the back of the wrist in pianists and about the thumb and the wrist in needlewomen. They form tense, elastic

swellings which may give rise to a good deal of aching and some disability. They move laterally with the tendon and vertically also when the fingers are moved. They may also occur in connection with joints ; this variety is most often seen about the back of the wrist, where they communicate with the synovial cavity. In this form the sac is often multilocular, whilst in those connected with the finger tendons it is usually single.

TREATMENT.—The simplest method of treatment is to burst the ganglion, and so disperse its contents into the cellular tissue, and then to favour obliteration of the cavity by pressure. This may sometimes be done when the wall of the sac is thin, and good pressure can be made against the subjacent bone. The swelling is squeezed against the bone by one or both thumbs ; if sufficient pressure be exerted, the ganglion suddenly gives way. The compression is maintained, and the part kneaded until the contents of the sac have been pressed out into the cellular tissue. A graduated compress is then applied, a piece of lint about the size of the ganglion being first placed over the spot, a somewhat larger piece outside, and then one larger still, until sufficient has been put on to enable the bandage to apply effectual pressure ; outside the last layer of lint may be placed a piece of metal or wood about the size of a penny, so as to press the walls of the sac together, in the hope that they will adhere. The bandage is left on for a week, and then nothing further is necessary. If the ganglion be cured, there will be no further trouble ; if not, it will refill. This treatment is successful in a considerable number of cases, and it should be tried as a first measure.

If the ganglion refill after rupture, or if the sac be too firm to burst, the next procedure is to puncture the skin with a fine tenotome at a little distance from the ganglion, make the knife pass right across the sac through the wall on the opposite side, and then to cut horizontally so as to divide the wall of the ganglion. The tenotomy knife is then withdrawn, and the contents of the sac are squeezed out into the cellular tissue. Collodion is painted over the skin puncture, and a pad and bandage are applied firmly over the seat of the ganglion as described above, and left on for about a week. The distribution of vessels and nerves in the vicinity must be borne in mind whilst performing this small operation, and in some situations this method cannot be employed lest injury to these structures should result. It is important to remember that the ganglion will refill if the sac wall be merely punctured ; a wide opening must be made, through which the contents can be evacuated into the cellular tissue around.

In some cases the ganglion persistently refills after rupture or division ; in others it may be so situated that it can neither be ruptured nor safely divided with a tenotome, on account of its proximity to important vessels. Apart from these points, the ganglion may be a multilocular one, in which one compartment has been evacuated, while others

remain and afterwards increase in size. In all these cases it is best to dissect out the sac. A curved incision is made over the swelling, a flap turned aside, the ganglion exposed, and its wall isolated with a dissector and cut away. In doing this, the sheath of the tendon is naturally opened, and, should the ganglion communicate with a joint, the articular cavity is also exposed; but if the operation be done antiseptically no trouble results. The wound is sutured without a drainage tube, and, as a rule, it is not necessary to put on a splint. Active and passive motion are begun after a few days, but there is little tendency for the tendon to adhere to its sheath.

CHAPTER IX.

AFFECTIONS OF TENDONS.

TRAUMATIC AFFECTIONS.

THE injuries of tendons which require consideration are division through an open wound, subcutaneous rupture, and dislocation. The treatment varies according as the injury is recent or old.

DIVISION OF TENDONS.

Injuries accompanied by division of tendons usually occur about the hand or the forearm; the tendon may be divided transversely or obliquely.

RECENT INJURIES.—The immediate result of the division of a tendon is loss of movement in the part to which the tendon is attached, and separation of the divided ends. This separation is entirely due to the retraction of the upper end caused by the contraction of the muscle from which the tendon takes its origin. The degree of separation depends partly on the anatomical arrangement of the tendon and partly on the length of the muscle; the longer the muscle, the greater will be the retraction. As regards the first point, some tendons have accessory connections with bones, or junctions with other tendons, and cannot therefore be drawn up, even when they are completely divided. For instance, there are fibrous bands passing between the three inner tendons of the extensor communis digitorum which prevent any marked degree of retraction of the divided ends. There are also bands running from the tendo Achillis to the bone above its main point of insertion, and these serve to keep the tendon more or less in position, if the wound be close to its insertion; on the other hand, if the division occur more than an inch above that point, there are no restraining bands of this kind, and there may be very marked separation, a gap of as much as an inch and a half being sometimes left between the divided ends.

When a tendon has been divided, and the ends remain in fairly close

apposition, the interval between them becomes filled up with clot, and young fibrous tissue forms between the ends in about a fortnight provided that there be no suppuration ; in five or six weeks this will be dense and able to bear considerable strain, and ultimately it comes to resemble closely the normal tendon in structure. In the absence of sepsis, the likelihood of a divided tendon uniting without surgical assistance depends to a great extent upon the particular tendon involved. For instance, the tendo Achillis unites much more readily than the flexors of the fingers when they are divided within their synovial sheaths. In the latter case, the ends of the tendon quickly contract adhesions to the sheath, unless they are brought close together, and their action is thereby much interfered with, and may be entirely lost.

Treatment.—When a tendon has been divided in an open wound, the patient should be placed under an anæsthetic as soon as possible, and steps taken to *render the wound aseptic* (see Vol. I. p. 164), because union will not take place should suppuration occur, even though the divided ends be brought into apposition. If the soft parts only be injured, it is better not to apply undiluted carbolic acid to the wound, unless the latter be extremely dirty, because necrosis of the ends of the tendons might result and interfere with satisfactory union.

Primary Tendon Suture.—The next step is to stitch the divided ends together. If the divided ends of a tendon be merely approximated, and not sutured, the result is seldom satisfactory ; the ends will almost certainly unite with the scar tissue, and, even if they do not, the lymph thrown out between the ends will not organise properly, and the function of the tendon will be seriously impaired. The first important point is to find the divided ends ; it is usually easy to find the distal end, but the proximal one often offers considerable difficulty. The description of the steps of the operation for tendon suture will be facilitated if we take as an example a case of transverse division across the front of the wrist. If the lower end of the divided tendon be not exposed in the wound, it will come into view on flexing the fingers and the wrist fully. When the cut end is seen, it should be seized with catch forceps, which are left on, so as to ensure its ready identification. The upper end is more difficult to find, because the muscle retracts at the time of the accident, and the tendon is often drawn up a long way within its sheath. The simplest plan is to extend the other fingers and squeeze the belly of the muscle forcibly downwards after flexing the elbow joint fully ; it may thus be possible to bring the tendon into reach and seize it with a pair of catch forceps. If this plan be unsuccessful, it will be necessary to lay open the sheath until the divided end is reached. When, however, slitting up the sheath is likely to damage important structures, a second incision should be made over the tendon, well above the wound, and the sheath opened ; from this incision the tendon is pushed down until its divided end appears in the original wound. Another useful plan

is to pass a probe, threaded with silk, through the tendon sheath from the original wound to the second incision. The ligature is fastened to the proximal portion of the tendon, and the probe is withdrawn. By making traction on the ligature, the proximal part of the tendon is pulled down into apposition with the distal part (see Fig. 25). When the two ends have been secured, they may be brought into apposition in a recent wound, without any undue tension, by relaxing the parts (in the example before us, by fully flexing the fingers, the wrist, and the elbow).

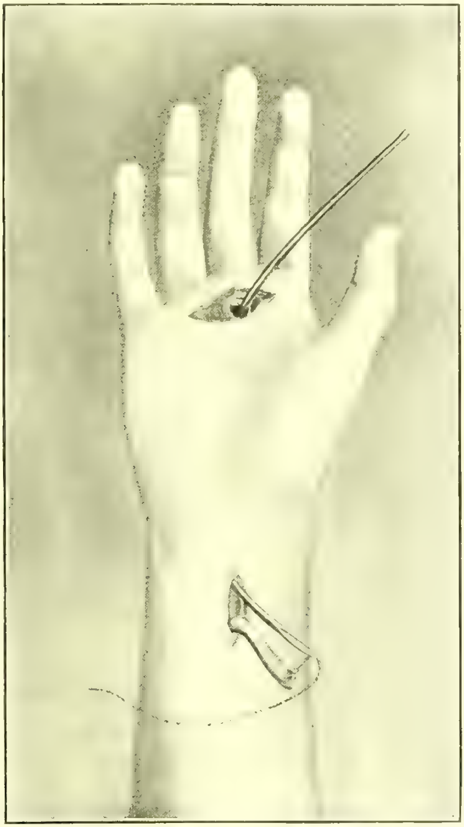


Fig. 25.—Method of finding the divided end of a Tendon. An incision has been made at the site of division and another over the same tendon in the forearm. A probe is then pushed up the tendon sheath from the first incision and made to emerge at the upper one. Into the eye of the probe is passed a suture tied to the proximal end of the tendon, which can then be pulled down to the distal end by withdrawing the probe.

The next point is to see that the divided ends are clean cut; if they be ragged, a clean section should be made with a sharp knife through each. The ends are then stitched together. If an ordinary interrupted suture be passed between the ends, the thread simply separates the fibres of the tendon as it is tightened, and cuts its way directly out, just as it does in the case of muscles. The needle should be passed across from front to back through the whole thickness of the tendon quite to one edge of it and close to the line of division, and the thread tied over the small piece of tendon included in the loop (see Fig. 26, *A*). A secure hold is thus obtained, and the thread may be pulled upon firmly without fear of its cutting its way out. A similar procedure should be adopted on the opposite side of the tendon, and both the upper and lower ends should be prepared in this way, care being taken that the sutures are inserted at exactly corresponding points in the two ends, so that the tendon is not twisted when they are tied together. The ends of the corresponding threads on each side are then tied so as to bring the two cut surfaces into apposition (see

Fig. 26, *B*). It is well also to put in one or two sutures in the centre to reinforce the lateral ones; these will prevent the cut surfaces from becoming displaced laterally or curled up, and they may be inserted in the ordinary manner, as they do not bear any strain.

The best material for uniting tendons is chromicised catgut, which undergoes absorption very slowly. Silk is sometimes used, but it is better to employ a material that is more quickly absorbed. The lateral stitches should be fairly stout, but the centre ones should be quite fine, in order that there shall be as little friction as possible between the tendon and its sheath.

When several tendons are divided in the same wound, it is necessary to make sure that the two ends united belong to the same muscle. There should be no difficulty about this if the tendons have been divided by the surgeon in the course of an operation such as tendon lengthening, or arthrectomy, as he will then take means to identify each tendon as it is divided by means of some such device as passing a thread through it, with or without a certain number of knots in it. In an accidental wound, however, such as a cut dividing all the tendons on the front of the wrist, it is often difficult to identify the corresponding ends of each tendon divided without an elaborate dissection.

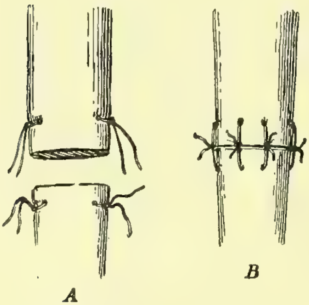


Fig. 26.—Tendon Suture. In *A* are shown the stout lateral stitches upon which the strain is thrown. In *B* the cut ends are approximated by tying the lateral stitches, and in addition, the finer coaptation stitches are put in.

The wound should be stitched up carefully so as to get union by first intention over the spot at which the division has occurred. If necessary a catgut drain may be placed in one corner of the wound so as to avoid the possibility of its becoming distended with serum or blood. If the wound be dirty when first seen, a drainage tube should be employed. The limb is fixed on a splint in such a position as to ensure full relaxation of all the muscles concerned. In the case of a wound on the front of the wrist, the upper arm, forearm, and hand may be fixed in a trough of poroplastic material or gutta-percha moulded to fit the limb, the elbow, fingers, and wrist being fully flexed.

After-treatment.—This position of extreme relaxation may be gradually altered by taking off the splint every two or three days, and increasing its angle slightly each time. In about a fortnight the patient should be encouraged to move the fingers, and gentle passive movement may also be begun. By that time some adhesions will have formed, but they are soft, and readily give way on stretching the fingers. It is essential not to use force enough to tear through the union in the tendon, but when the stitching has been done as recommended above, there is not much risk

of such an accident. From this time onward, active movements of the fingers by the patient himself is of great help, and passive movement must be employed once or twice a day. Complete restoration of function may result if this treatment be carried out carefully and assiduously.

OLD INJURIES.—When a considerable time has elapsed after the receipt of the injury and union has not occurred, it is often extremely difficult to secure a satisfactory result, whether there was in the first instance an open wound or a subcutaneous rupture. The only possible chance of success lies in operation, the chief difficulty being to find the divided ends and bring them into apposition. All scar tissue present should be dissected out as completely as possible, as the uninjured tendons frequently act better after an operation has been performed to unite a divided one, because their action has generally been impeded by adhesion to the original scar tissue.

Secondary Tendon Suture.—For purposes of illustration we shall take a case of division of a tendon in front of the wrist, when no union has occurred, and where the ends of the tendon are not even adherent to the scar. An incision should be made directly in the line of the tendon; if there be no scar tissue, it is well to make it crescentic, so that the incision in the skin and fascia does not correspond to the point in the tendon at which suture is to be practised (see Fig. 27); this will avoid adhesion between the line of suture and the cutaneous scar. Extensive dissection is often required to expose the divided ends. In the example we are considering, the lower portion of the tendon will be behind the annular ligament, possibly in the palm, and the upper one will be some considerable distance up the sheath; both ends will be firmly adherent to the structures in their immediate neighbourhood. The search for the upper end is facilitated by prolonging the skin incision upwards over the lower end of the belly of the muscle; by following this down, the tendon may be found. Its sheath can then be opened, the end freed from any adhesions it has contracted, and enough removed to provide a freshly-cut surface. The distal portion of the tendon is then sought for and treated similarly. In the example before us it may be difficult to find the lower end behind the annular ligament, this difficulty depending largely upon the position in which the fingers were when the tendon was divided. If division occurs when the fingers are extended, the distal end remains almost directly beneath the wound; but if the fingers are flexed at the moment of division the action of the extensors in straightening the fingers, pulls

FIG. 27. — FLAP FOR OPERATIONS UPON RUPTURED TENDONS. The incision *ab* marks out a flap which, when turned back, exposes the cicatricial tissue between the ends of the tendon (shaded in the diagram) well away from the line of division of the skin.

the lower end of the tendon down the sheath beneath the annular ligament. The cut end can be exposed by dividing this structure, but a better plan is to expose the tendon in the palm; then the point at which adhesion has taken place may be found by pushing a probe up the sheath and an attempt may be made to make the probe protrude into the upper wound and form a guide along which the tissues can be turned aside, and the end of the tendon freed. When the end has been secured and the adhesions freed, it is always possible to pull the tendon up into the wound, because the distal end is not shortened; the gap between the divided ends is due to contraction of the muscular fibres and this only affects the proximal portion.

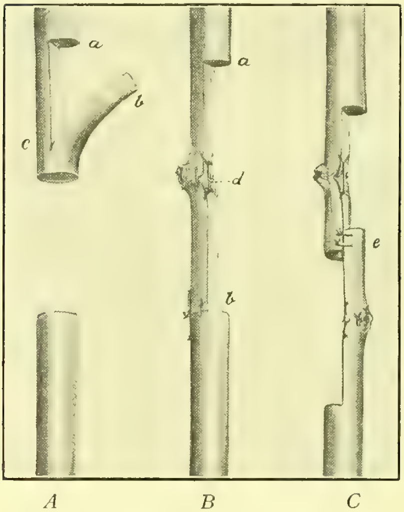


FIG. 28.—METHOD OF LENGTHENING A TENDON. In *A* the tendon has been divided and one end has been cut half through at (*a*) by a transverse incision; a second incision has been carried to (*c*) so as to enable a flap (*b*) to be turned downwards. In *B* this flap has been sutured to the lower end of the tendon, supporting sutures being inserted at (*d*) so as to prevent the complete detachment of the flap. In *C* the same operation has been performed, but flaps have been turned to meet each other at both ends (*e*) of the divided tendon.

The Flap Method. — When the distal portion has been freed and brought into the wound, its end must be prepared in a manner similar to that employed for the proximal portion. As a rule approximation cannot be secured by the method recommended for recent cases, as the shortening of the muscle does not allow the ends to be brought into apposition without danger of the stitches cutting out. The simplest way of overcoming this difficulty is to split the proximal end of the tendon and turn down a piece sufficiently long to meet the distal portion without undue tension. This may be done by making a transverse incision half-way across the tendon, one to two inches above the free end of the proximal portion of the divided tendon, according to the amount of shortening present. From the centre point of the tendon the incision is carried vertically downwards to within a quarter of an inch of the end (see Fig. 28, *A*). A flap is thus turned down, but it would easily become completely separated if any pull were made upon it, and, therefore it is well to insert one or two catgut stitches between the sides of the vertical incision at its lower end where the tendon might split (see Fig. 28, *B*). The reflected flap of tendon should be stitched to the distal portion in the manner already described (see p. 93), the fingers and wrist being fully flexed to obviate tension. In cases in which there is wide separation it

is often necessary to turn up a similar flap from the distal portion also ; if this has to be done, it is well to make the two flaps longer than necessary, so that one overlaps the other. One or two fine catgut stitches between the adjacent sides will then give satisfactory union (see Fig. 28, *C*).

After-treatment.—The wound is stitched up without a drainage tube, and the fingers and wrist, which are at first fully flexed, are gradually extended ; in a few days gentle active and passive movements are begun. When tendons have been lengthened, great care must be taken not to tear away the flap of tendon while practising movements, but that danger is minimised when lateral sutures are employed as for the union of recently divided tendons (see p. 93).

Bridging with Catgut.—Cases occur, however, in which this method is insufficient. A plan which occasionally yields fairly good results, when there is a long tendon enclosed in a sheath, is the following (see Fig. 29). After the ends of the tendon have been freed, they are approximated as much as possible by the lateral stitches already described (see p. 93). A long piece of catgut is then taken and the needle passed backwards and forwards from one end of the tendon to the other several times, so that the gap between the ends is bridged by a number of catgut strands. The result is that lymph and blood are poured out amongst the catgut threads, and the lymph and the catgut itself become organised. In these cases, as in the others, it is well to reduce the flexion of the limb gradually and, after two or three weeks, active and passive movements may be commenced. There is no likelihood of the stitches cutting through at all quickly.

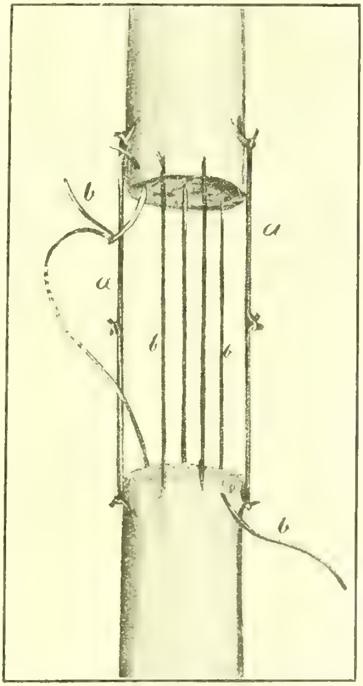


Fig. 29.—Method of darning a gap in a Tendon. Tension sutures are inserted at (*a a*), and a continuous suture (*b b*) is then passed so as to darn the space between the ends of the tendons.

Division of Muscle.—When a single tendon only has been divided and the muscle has undergone considerable shortening, it may be necessary also to divide the belly of the muscle in the zigzag manner described on p. 69. By this means very considerable lengthening may be obtained, but to secure a good result much care and perseverance are required in the after-treatment.

Implantation.—When it is impossible to reconstruct the tendon by one of these methods, restoration of function may sometimes be obtained by attaching the distal end of the divided tendon to a neighbouring sound one. For example, when one of the tendons of the flexor profundus digitorum has been divided and a considerable portion of it has been lost, its lower end should be defined and refreshed; the side of the neighbouring uninjured tendon of the same muscle should then be made raw, and the two tendons united laterally by fine catgut stitches (see Fig. 30). Another way of carrying out the same procedure is to split the healthy tendon, and

Fig. 30.—Lateral Suture of Tendons. In this method the two tendons are applied to one another and kept in position by sutures. The side of the uninjured tendon is made raw to receive the end of the divided one.

Fig. 31.—Lateral Implantation of Tendon. The smaller tendon is threaded through a vertical incision in the larger one and is then divided into two flaps which are turned upwards and downwards, and sutured in the manner shown.

to insert the distal end of the divided one between the two halves of the split tendon and stitch it in place after paring the former (see Fig. 31). The fingers must be fully flexed so as to relax all tension during union. If the operation be successful, the muscle pulls not only on the uninjured tendons, but also on the newly attached one, and as the function of all four tendons is the same, a uniform flexion of all the fingers is obtained; the power of flexing the affected finger independently of the others, however, is lost.

Transplantation.—Transplantation of tendons has been practised when there is a considerable loss of tendon. A piece is split off from a neighbouring tendon and stitched to each end of the one divided; or a

tendon from one of the lower animals may be employed in a similar manner. In tendons, however, the blood-vessels are too few for the new piece to become quickly vascularised in the same manner as a skin-graft, and thus the plan really acts in much the same way as the strands of catgut just described. It is hardly likely that the detached portion of tendon will retain its vitality ; it probably only serves as a guide for the new tissue and as pabulum for the cells. Further, on account of its thickness and size, it is less likely to be eaten up and replaced quickly than is catgut, and, therefore, it is apt to act as a foreign body. When transplantation is employed, lateral stitches holding the two ends of the original tendon in position, and also giving support when the time arrives for passive motion, must be inserted.

When all other attempts at uniting the divided ends have proved fruitless, both ends of the divided tendon have been attached to the scar, so that, when the muscle contracts, it pulls upon the scar and, through this, upon the distal end of the tendon. This method should only be adopted when nothing else can be done.

RUPTURE OF TENDONS.

A tendon may rupture as a result of irregular and violent muscular contraction. For example, when a person in falling tries to retain his balance, he sometimes ruptures the ligamentum patellæ ; indeed, this is more common than rupture of the quadriceps extensor muscle itself. Other tendons which are frequently ruptured are the tendo Achillis, about an inch and a half from its insertion into the os calcis, the plantaris and the long head of the biceps cubiti.

TREATMENT.—This may be carried out either by position, in which the object is to bring the ends into as good apposition as possible, or by operation, in which the ends of the tendon are stitched together. In deciding upon the method to adopt, a good deal will depend upon the tendon ruptured, and the exact point at which the rupture has occurred. For example, union readily follows rupture of the tendo Achillis without any need for operative interference ; this is explained by the fact that the tendon runs in loose cellular tissue. On the other hand, rupture of the quadriceps femoris tendon rarely gives a really satisfactory result if treated by position alone. With the latter form of treatment the worst results are obtained in the case of tendons, such as those of the fingers and thumb, which run in long rigid tendon sheaths ; in these cases union is rare. This fact must also be borne in mind in performing tenotomy ; these particular tendons should not be divided opposite the fingers or in parts where the ends are free to retract for a long distance ; when possible they should be divided in the forearm.

As the treatment must vary with the tendon divided we shall describe

in detail that appropriate for rupture of the tendo Achillis, the ligamentum patellæ, the biceps flexor cubiti, and the plantaris.

Rupture of the Tendo Achillis.—In rupture of the tendo Achillis, treatment by position is usually sufficient. A leather strap, furnished with a buckle or ring, or a band of strapping is secured around the thigh. A loop is fastened to this opposite the centre of the posterior aspect of the limb, and a slipper with a loop attached to its heel is put on the foot. A piece of elastic bandage or india-rubber tubing is attached to these loops and thus the heel is drawn up and the knee is flexed (see Fig. 32); the divided ends of the tendon are thus brought into fairly good apposition, though they are not absolutely in contact, and union occurs satisfactorily.

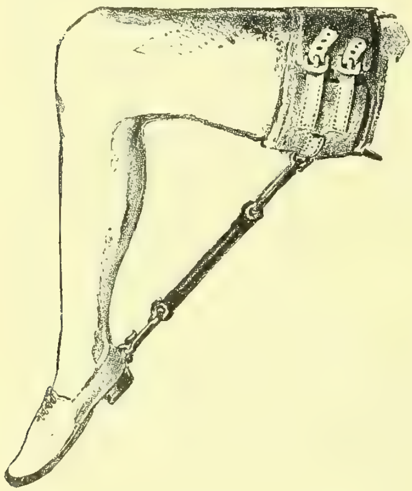


FIG. 32.—RUPTURE OF THE TENDO ACHILLIS TREATED BY POSITION. Should the thigh-band tend to slip, as it often will from wasting of the muscles, it may be kept in position by fastening it to a band round the waist.

This apparatus must be kept on continuously for about a fortnight, and then the tension of the elastic should be diminished and the patient encouraged to move the ankle joint. The apparatus may be left off in about three weeks, but the patient should not be allowed to stand on the foot until five weeks have elapsed from the time of the injury. At the end of the third, however, he should be encouraged to move the foot, while a certain amount of passive movement may be practised with the object of preventing adhesion of the newly-formed tendon to the surrounding parts. After five weeks he may be allowed to walk about, at first with the assistance of a crutch or stick. In many cases complete restoration of function occurs without any massage being required.

Non-union may follow rupture of the tendo Achillis, either because the case has not been treated, or because treatment has failed to secure a good result and, therefore, it may be necessary to operate in order to obtain restoration of function. The operation should be on the lines laid down for the union of tendons after division in an open wound (see p. 93). As there is no scar here, it is well to use a curved incision so that the incision in the skin is as far away as possible from the line of union in the tendon. In the case of the tendo Achillis, a curved incision is made with the convexity extending well over to the outer side of the limb, the centre

of the curve being opposite the point at which it is hoped to unite the tendon, and the ends being well beyond the inner border of the tendon. A flap of skin, with the superficial and deep fascia, is turned inwards, and then the divided ends of the tendon are sought for, the fibrous tissue removed, and the ends united.

Rupture of the Ligamentum Patellæ.—In the ligamentum patellæ, on the other hand, the employment of position alone seldom yields a satisfactory result, and it is therefore well, whenever possible, to perform immediate suture of the tendon. As a rule the tendon is torn off at or

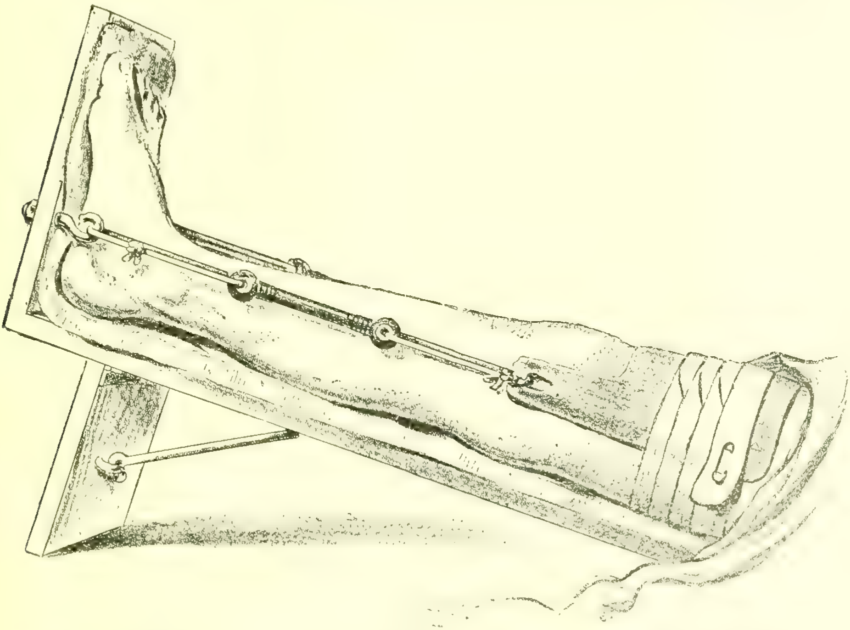


FIG. 33.—RUPTURE OF THE LIGAMENTUM PATELLÆ TREATED BY POSITION. For the sake of clearness the bandages fastening the limb to the splint have been omitted.

close to the patella, and the operation may involve opening the knee joint. The curved incision should have its convexity upwards, and its lower limit should be below the tuberosity of the tibia. The flap is turned down, the torn ligament exposed, any loose tags of tendon are clipped away, and the latter is united in the manner already described (see p. 93). In a broad tendon like the ligamentum patellæ, it is advisable not merely to have a fixation suture at each side, but also one or two in the central part; a continuous catgut suture should be inserted in the intervals between these.

After the wound has been closed, the leg is placed on a back splint, which is raised on a pillow or rest, in order to relax the quadriceps extensor fully. The splint is gradually lowered, until, at the end of the first fortnight, it lies flat on the bed. The splint may be left off in three weeks

after the operation, and the patient encouraged to move the limb in bed, but he should not be allowed to get about until six weeks have elapsed from the time of the injury.

This is the best method of treatment when the patient is healthy and vigorous, and the asepsis of the wound can be depended upon. But when the surgeon has not sufficient confidence in his asepsis, when the patient objects, or when his health is such that operation is deemed inadvisable, the case should be treated in the following manner. The limb is shaved, and a broad piece of strapping is fixed over the front of the thigh, extending about half-way up the limb and reaching down to the tubercle of the tibia. The portion which lies over the patella is cut away so that the lower end of the strapping is horse-shoe in shape, the sides of the horse-shoe surrounding the upper and lateral borders of that bone. The strapping is bandaged to the thigh, and tapes are sewn to it on each side of the patella, and to these the extension apparatus is attached. The limb is then placed on a back splint with a foot-piece at right angles, and at the sides of the foot-piece, close to the heel, holes are bored or bars are fitted, to which the extension apparatus can be attached. One end of a piece of india-rubber tubing is tied to each of the tapes just mentioned, and the other attached to the foot-piece of the splint or the bars upon it (see Fig. 33). By tightening these, any degree of tension required can be employed, and the idea of the apparatus is that traction on the strapping brings down the patella. The limb is kept considerably elevated, so as to relax the quadriceps extensor femoris. The apparatus is kept on for about six weeks, the limb being gradually lowered during that time. When the patient begins to walk, the flexion of the joint must be increased very slowly, lest the union should give way again.

When rupture of the ligamentum patellæ has occurred a considerable time before the patient comes under notice, and no proper union has resulted, an operation should be done in the manner just described (see p. 101). In some cases it will be found that the short upper portion has curled up and become so matted to the tissues around that it is impossible to define it properly and get satisfactory approximation. Under these circumstances a drill may be passed transversely through the tubercle of the tibia and another transversely through the lower end of the patella, and a loop of strong silver wire passed through the drill holes, and twisted up tightly. The remains of the ligamentum patellæ are then united by sutures and the wound closed. The patient may be allowed to walk about from the third week onwards, reliance being placed on the silver wire to act as a ligamentum patellæ.

Rupture of the Long Head of the Biceps Cubiti.—The long head of the biceps cubiti is generally torn from its scapular attachment, and no method of treatment by position is completely satisfactory. The plan in general use is to fix the arm across the chest, the shoulder and the

elbow being fully flexed, but, as may be imagined, union is not satisfactory, because the end of the tendon is pulled away from its attachment to the glenoid cavity. The only way in which a completely satisfactory result can be looked for is by operation, which is, however, very difficult. It involved opening the shoulder joint, and it is very doubtful whether the disability of the limb caused by rupture of this tendon, is so great as to make such an elaborate operation worth while. Should the disability caused by the accident be so great that the patient desires an operation, it would be justifiable to do it ; but each case must be judged upon its merits, and no definite rules can be laid down.

When the disability is only slight, it is not worth while putting the patient to the inconvenience entailed by putting up the limb for a prolonged period with the elbow fully flexed and the arm fixed across the chest, since by these means it is impossible to secure apposition of the torn ends of the tendon which will have retracted at the time the rupture takes place. Treatment by position of this kind is likely to give rise to adhesions, and it is, therefore, better to treat the case by massage and movements from the first, the forearm being carried in a sling for about a fortnight.

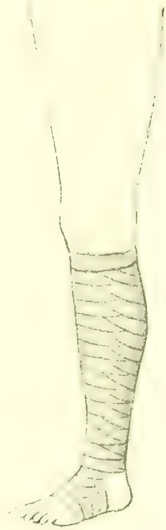


Fig. 34.—Method of Strapping the Limb in Rupture of the Plantaris Tendon.

Rupture of the Plantaris Tendon.—This may occur as the result of sudden muscular action. It is not uncommon in tennis players. A sudden sharp pain, which is generally compared to being hit by the ball, is felt in the calf ; the limb may subsequently become swollen. The treatment is to strap the limb from the balls of the toes to just below the knee (see Fig. 34). The leg should be shaved before applying the strapping, which is put on in strips overlapping one another, It is kept on for three to four weeks, being renewed when necessary. The patient may go about with the strapping on ; massage may be required after it is removed.

DISLOCATION OF TENDONS.

The tendons most liable to displacement from violence are the peroneus longus at the outer ankle, and the long head of the biceps cubiti, which may become dislocated from the bicipital groove ; both these accidents are important as they give rise to much disability.

DISLOCATION OF THE PERONEUS LONGUS TENDON is the more common accident, and usually results from the patient

trying to regain his balance ; a sudden forcible movement when the foot is everted, such as a fall in which the foot suddenly reaches the ground in an everted position, is very apt to dislocate the tendon from its groove. When the accident occurs there is a sensation of tearing, accompanied by sudden pain and a certain amount of loss of power in the foot. Very often, too, there is a subfascial hæmorrhage and considerable swelling, so that, unless the case be seen early, the exact injury cannot be diagnosed until two or three weeks have elapsed ; it is then found that a tendon which ought not to be there rolls about under the finger on the outer side of the malleolus.

Treatment.—The treatment consists in replacing the tendon in its groove and keeping it there by artificial means until the rent in the sheath has united. This may be done either by replacing it by manipulation, and afterwards fixing the foot in the inverted position, or by means of operation. Without operation it is very difficult to get the tendon into place satisfactorily and to keep it there afterwards ; and, as considerable swelling generally follows the injury, it may readily slip out again and the displacement not be recognised until the swelling subsides some weeks later. Hence *immediate operation* is the better procedure.

A curved incision is made with the convexity forwards, and a flap turned back, so as to expose the groove behind the external malleolus. The tendon can then be readily replaced in position after everting and extending the foot ; the edge of the torn sheath must not be allowed to roll up between the tendon and its groove. The torn edges of the sheath should then be brought together over the tendon by a continuous catgut suture. The foot is brought to a right angle and strongly inverted, and is maintained in this position by a poroplastic splint moulded to the outer side of the leg and foot. The limb is not touched for ten days, when the stitches are removed and daily active and passive movements are begun. The thumb should be firmly pressed over the tendon whilst movement is being practised, and the foot should be kept well inverted ; after the movements have been carried out the splint is re-applied. It is advisable not to allow walking or to leave the foot out of the splint permanently, until about six weeks after the operation, so as to give time for the union of the sheath to become firm.

When the tendon has been dislocated for some weeks, it is extremely difficult to return it to its groove, and to keep it in position afterwards. The groove becomes filled up with new tissue, remains of the sheath, etc., and, therefore, even when the tendon has been got into position, there is a constant tendency for it to slip out at once, because there is no proper groove for it to lie in. When, therefore, it is possible to get the tendon into position by operation, it will be necessary to deepen the groove in the external malleolus in order to keep it there. The soft tissue which fills up the groove is first dissected away, and then a fine gouge is

made to cut a channel out of the bone as wide as the original groove, but deep enough to make it difficult for the tendon to slip out when it has once been replaced. The tendon is then laid into this groove, any soft fascial tissue present stitched over it to form a sheath, the incision closed and the foot put up flexed and inverted as in the previous case. Passive motion should be begun quite early, as otherwise the tendon is likely to become adherent to the bone ; certainly not more than a week should be allowed to elapse before active and passive motions are commenced, and they should be carried out daily for about three or four weeks after the operation, the splint being continued in the intervals. At the end of that time the splint is left off, and the patient encouraged to move the foot often and to walk about a little, keeping the foot carefully inverted while he does so. Passive motion is required for about eight weeks after the operation.

When a longer period has elapsed since the injury, it may be impossible to replace the tendon in the groove, on account of the shortening of the muscle. In these difficult cases the following procedure has been adopted successfully. The groove in the bone is cleared and deepened, as described above. The tendon is divided very obliquely, and the two ends are brought over the outer malleolus into the groove prepared for them and stitched together. If the incision in the tendon be sufficiently oblique, the two ends are not actually separated as they lie in the groove, but overlap slightly. These overlapping ends are fastened together by fine lateral catgut sutures (see Fig. 35).

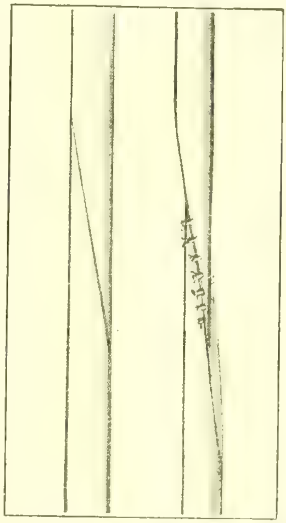


Fig. 35.—Lengthening a Tendon by Oblique Division.

Lengthening of the tendon may also be carried out in another manner, which is often more suitable than the method by oblique section. The tendon is split vertically in the middle line for a distance rather more than half an inch longer than the interval required. At each end of the vertical incision a transverse cut is made in opposite directions (see Fig 36), dividing half the tendon across. This gives a ⅂-shaped incision through the tendon, the two ends of which are then separated sufficiently, and the overlapping parts fastened together by lateral catgut sutures. The after-treatment is similar to that just described.

When no operation is thought desirable, or when the patient will not consent to one, the surgeon must content himself with using apparatus. The tendon is readily replaced in the early stage by flexing and everting

the foot and pressing the tendon into the groove ; the foot is then strongly inverted and brought nearly to a right angle. A firm pad is fixed over the groove so as to prevent the tendon from escaping, and an external poroplastic splint applied so as to fix the ankle joint. The splint should not be left off for about six weeks, except for passive motion, which is carried out in the same way as after operation, and then the foot and ankle should be strapped for some time, and the patient cautioned to walk about with the foot inverted.

DISLOCATION OF THE LONG HEAD OF THE BICEPS gives rise to considerable pain and disability, and the tendon cannot be replaced satisfactorily and kept in position except by means of an operation.

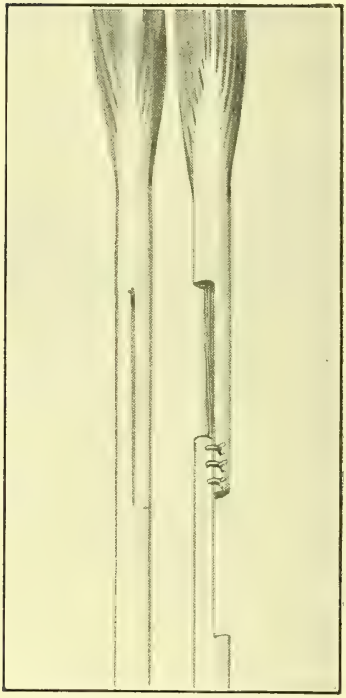


Fig. 36.—Lengthening a Tendon by L-shaped Section.

Treatment.—In order to obtain access to the spot at which the tendon has slipped out of its groove (which is usually above the insertion of the latissimus dorsi and the pectoralis major) an incision should be made from the coracoid process downwards along the anterior border of the deltoid, the deep fascia divided, and the muscle pulled to the outer side ; the bicipital groove can be felt and its groove exposed. The tendon is readily replaced and the rent in the sheath closed over it by means of a continuous catgut suture. The arm should be put up with the hand on the opposite shoulder, and the elbow raised, while the limb is fixed to the chest with a bandage, over which starch solution is applied. As soon as the wound has healed the patient should be encouraged to move the arm, which may be left loose for the greater part of the day. At night, however, it should be firmly bound to the side in the above position, because during sleep some sudden movement might lead to the escape of the tendon from its sheath once more.

TENDON GRAFTING.

This operation has been dealt with fully in Vol. I. p. 340 in connection with deformity after infantile paralysis.

INFLAMMATORY, SYPHILITIC, AND TUBERCULOUS AFFECTIONS.

These affections of tendons are secondary to similar affections of their sheaths. As we have already discussed these in the previous chapter, they need no further mention here.

CHAPTER X.

AFFECTIONS OF NERVES.

TRAUMATIC AFFECTIONS.

As far as treatment is concerned, the traumatic affections of nerves may be considered under three heads—Compression, Contusion, and Division of nerves. These groups overlap each other considerably both as regards symptoms and treatment, but, nevertheless, the subject will be made clearer by treating each independently.

COMPRESSION OF NERVES.

A nerve may be subjected to so much pressure that its functions are materially interfered with for a time at any rate, and under these circumstances certain pathological changes occur in it. The nerve may be compressed anywhere in its course, but, from the point of view of symptoms and treatment, it is only necessary to consider compression affecting the trunk of a nerve or its terminal filaments. The compressing force may be severe, and may produce its results rapidly, or it may be milder, and the results may appear more slowly. The compression may be due to injury or to some pathological process. We shall describe (1) Compression of nerve trunks—this will be divided into Traumatic Compression, both rapid and gradual, and Pathological Compression ; (2) Compression of the terminal filaments of nerves.

COMPRESSION OF NERVE TRUNKS.—(*a*) **Rapid Traumatic Compression.**—Here the pressure to which the nerve is subjected is severe, and, although lasting for only a short time, may produce profound changes in the injured nerve. It is probable that there is an actual contusion, the pressure of the nerve against an adjacent bone leading either to rupture and disorganisation, or to effusion of blood in and around its fibres ; as an example may be mentioned what is popularly spoken of as ' drunkard's ' or ' Saturday night palsy.' The nerve compressed is generally the *musculo-*

spiral; the patient falls asleep or becomes insensible, with the back of the upper arm resting against or hanging over the edge of a chair or table, and the result is that the sharp edge presses the musculo-spiral nerve against the shaft of the humerus, and produces a more or less temporary paralysis of that nerve. Sometimes under similar circumstances other branches of the *brachial plexus* may be affected, as, for example, when the patient sleeps with his hands behind his head, and the head of the humerus presses on the nerves in the axilla. This, however, is much more uncommon than compression of the musculo-spiral. If the hands be tied above the head during anæsthesia, the brachial plexus may be compressed by the humerus, and paralysis will follow. Recovery without operation is the rule in these cases. Dislocation of the humerus forwards or downwards may be followed by paralysis. Another example of rapid compression is seen in certain cases of *fracture*, in which a nerve trunk is suddenly compressed against one of the fragments without being actually torn; this leads to temporary paralysis of the parts supplied by the affected nerve. Again, during *parturition*, temporary paralysis may occur in the lower extremities of the mother, as the result of the pressure of the fœtal head upon the sacral plexus; in the child there may be paralysis of the facial nerve from pressure of the forceps.

(*b*) **Gradual Traumatic Compression of Nerve Trunks.**—The best example of this form of compression is seen in *crutch palsy*, which is due to the long-continued use of ill-fitting crutches. It comes on slowly and occurs chiefly when the arm-pieces of the crutches are insufficiently padded, or when the crutch is too long for the patient. The affection is probably a slowly developing neuritis, leading to degeneration and atrophy of the nerve filaments.

(*c*) **Pathological Compression of Nerve Trunks.**—When the compression of nerves is the result of morbid processes, the symptoms come on slowly. Perhaps the commonest example of this is compression of a nerve by the *contraction of fibrous tissue* during the healing of a wound, or by the *callus* surrounding a fracture, which may either stretch the nerve running over it, or may surround and press upon it. Similarly, *tumours* may compress nerves, and malignant tumours may actually destroy them. In pathological compression the result produced is due either to interference with the blood supply of the nerve (as occurs when the latter is stretched over some firm structure), resulting in fatty degeneration and disorganisation of the nerve fibres, or it may be due to a neuritis set up by the pressure.

COMPRESSION OF THE TERMINAL FILAMENTS OF NERVES.—This generally results from some pathological process, and is most commonly due to involvement of the terminations of the nerves in *cicatrices*, or, more rarely, in *malignant tumours* of the skin. The sensory nerves are chiefly affected, and the entanglement of nerves in scars and the

pressure thereby produced on them usually ends in the production of a neuritis spreading up to the trunk of the nerve.

Symptoms.—However produced, compression of a large trunk nerve gives rise to symptoms which vary according as the nerve is sensory, motor, or mixed; in the latter case the sensory filaments are usually the first affected. In the case of a sensory nerve, the patient first complains of neuralgia in the part supplied by the nerve, followed by sensations of heat and cold, numbness, hyperæsthesia, and subsequently complete anæsthesia. In a mixed nerve, the sensory disturbance is followed at a somewhat later period by motor paralysis; this is slight at first, but it gradually increases in degree as the compression advances. If the compression and its effects—that is to say, neuritis—still continue, trophic changes, such as the formation of bullæ, ulcerations of the skin, wasting of muscles, and so forth, may take place in the parts supplied by the nerve.

When nerve-endings are implicated in cicatrices or malignant growths of the skin, the symptoms are generally great pain, hyperæsthesia, excessive tenderness on pressure, reflex pain in distant parts, convulsive twitching of muscles or even of the whole limb, and, in rare cases, epileptiform convulsions.

Treatment.—**Prophylaxis.**—The dangers resulting from the compression of nerves should always be present to the mind of the surgeon, and must be guarded against wherever possible. In applying compression to a limb the possibility of injury to the nerve should always be remembered; for example, if a narrow tourniquet or elastic tube be tightly applied to the upper arm, the nerves are apt to suffer injurious pressure because of their exposed situations. Hence, tubing should not be used as a tourniquet here, but a broad piece of elastic webbing should be employed in its place; this will exercise sufficiently firm pressure, but will do no harm, since the pressure is diffused owing to its breadth. Again, the possibility of crutch palsy in a patient compelled to use crutches must be borne in mind, and special care must be taken to see that the crutches are not too long for the patient, and that the arms are sufficiently padded. It is also very important to have handles or rests fitted to the crutches at a proper height, so that the palms may be made to bear the pressure, and not the axillæ. In fractures also, the possibility of the inclusion of a nerve between the broken ends of the bones, or of subsequent inclusion of the nerve in the callus must not be lost sight of. When reducing the fracture, care must be taken to see that no soft tissues are left between the bones, and directly symptoms pointing to compression of a nerve make their appearance, steps should be taken to remedy it, even should this involve operative interference.

When there is a chance of the terminations of a nerve becoming involved in a cicatrix and leading to a painful scar, every possible means of promoting rapid healing, more especially the avoidance of sepsis, must be had recourse to. When the edges of a wound can be brought

together, healing by first intention should be aimed at ; when this cannot be done, immediate skin-grafting should be practised, in order to diminish the subsequent contraction.

When Compression has already produced its effect.—After the compression has been relieved, recovery will almost certainly occur unless the nerve has been severely disorganised. Weeks or even months, however, may elapse before recovery is complete. Usually in such accidents as pressure on the musculo-spiral nerve from the edge of a table, recovery begins in about three weeks, and is complete in five or six ; but when the compression has been severe, months, or even years, may elapse before the nerve regains its normal condition.

During the interval preceding recovery it is extremely important to maintain the nutrition both of the nerve itself and of the parts supplied by it. The nutrition of the nerve trunk may be improved and the restoration of its functions expedited by the use of the *galvanic current* ; a current of not more than five milliampères should be applied for about ten minutes, and gradually increased in strength and duration as is found desirable. The current should flow downwards in the course of the nerve : *i.e.* the positive electrode is applied to the spine while the negative is on the affected nerve near its termination. The circuit should be opened and closed at intervals ; this produces muscular action, and thus helps to keep up the tone of the muscles.

The nutrition of the muscles supplied by the nerve is best maintained by *massage*, and steps must be taken to prevent contracture, which is apt to occur in consequence of the loss of the nerve supply ; unless proper steps be taken to prevent it, this may be permanent even after the nerve has completely recovered its functions. Massage of a paralysed muscle is very beneficial, as it improves its circulation, gets rid of waste products, and thus promotes its nutrition. The faradaic current, used in a strength sufficient to keep the muscle gently in action, but not strong enough to exhaust it, is also very useful. Should the muscle show ' the reaction of degeneration ' (*i.e.* loss of contractility to the faradaic current with coincident increase of contractility to the galvanic current), the galvanic current ought to be employed ; under these circumstances the circuit should be furnished with a key for opening and closing the current frequently (*vide supra*). At the same time *active and passive movements* of the affected limb should be encouraged, passive motion especially being diligently practised with the view of preventing contractures and adhesions in the neighbouring joints. During the night, the limb should be put on a splint in such a position as to oppose the tendency to contracture.

Careful treatment on these lines should be persevered with until the functions of the nerve have been restored, however long a time may elapse before the restoration occurs ; unless this be done, it may be found that by the time the nerve has regained its functions, the parts on which it acts have become irretrievably damaged.

When the Compression still continues.—When, for example, the nerve is involved in callus, steps must be taken to *relieve the compression* as quickly as possible; an incision should be made over the fracture, the nerve exposed above and below the callus, and traced over or through it. The new bone that is exerting the pressure must be removed, but in doing this special care must be taken not to damage the nerve as it runs through the callus. The main trunk and any of its branches, which may have become involved, should be followed out and set free, and then it is well to grasp it above and below the seat of compression and stretch it *in situ*, so as to rupture any new connective tissue around it that might exert injurious pressure. It is a good plan to wrap as much muscle as possible around the nerve, so as to prevent the callus compressing it again.

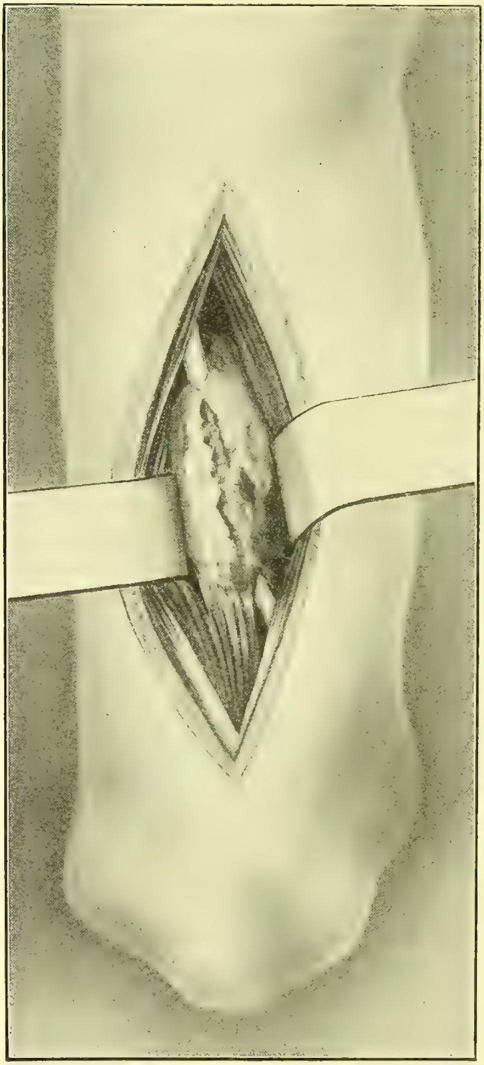


Fig. 37.—Method of Freeing a Nerve imbedded in Callus. The musculo-spiral nerve, which is involved in callus resulting from a fracture of the humerus, is exposed above and below the mass. The callus is then carefully cut away over it until the nerve is free.

If the cause of compression be a new growth, the growth must naturally be removed. When a simple tumour presses upon a nerve trunk it must be removed without dividing the nerve; if the nerve be embedded in the growth, it must be freed from the growth first, and then the growth is removed. Should the growth be malignant, however, the portion of the nerve implicated must be cut away and, if the condition of the parts permits, immediate suture of the divided ends should be effected by one of methods described below (see p. 119).

When a cicatrix is causing compression of a main nerve trunk, the nerve and any branches that may be involved must be freed just as is done when the compression is caused by callus. When only the terminal filaments of the nerve are involved in cicatricial tissue, the best plan is to *dissect out the scar* freely; this removes the ends of the nerves that are pressed upon. When the end of a nerve is involved in the scar of an amputation, it is advisable, in addition, to excise a portion of the nerve, so that it cannot be compressed again.

The wound is then closed, so as to secure union by first intention; if necessary a plastic operation or immediate skin-grafting may be employed, so as to ensure a minimum amount of fresh cicatricial tissue. Operation must be undertaken before neuritis has become established, otherwise it will be useless.

Division of the filaments of the nerve implicated in the scar with a tenotomy knife introduced beneath it often fails to divide all the filaments involved, and, moreover, the divided nerves may unite, when the patient's troubles will recur.

When the Cause cannot be removed.—When it is impossible to remove the cause of compression, the treatment will depend upon whether a motor or a sensory nerve is involved. If it be a motor nerve alone, no interference is called for, but if a sensory or a mixed nerve be affected, the compression may cause so much pain and hyperæsthesia, and may set up such a severe ascending neuritis, that something must be done to give the patient relief. Not only is the pain intolerable if the case be left alone, but the neuritis set up by the compression is apt to spread up the trunk and involve other branches of the nerve, and thus to extend the painful area.

Under these circumstances the advisability of dividing the nerve above the area of compression must be considered. Experience shows that it is better to resect a portion of the nerve than merely to divide it—in other words, *neurectomy* is a better operation than neurotomy. In a mixed nerve this, of course, abolishes the motor as well as the sensory functions, but paralysis of motion is already present when the nerve is badly compressed, and the abolition of sensation is what is desired by the patient. Whenever it is possible, therefore, the nerve should be exposed above the seat of compression, and a portion removed. In some cases, however, the nerve cannot be exposed above the seat of pressure, as, for example, when an inoperable intra-pelvic tumour presses upon the sacral plexus. In these cases, however, and also in those in which the pain has recurred after a previous neurectomy, it may be advisable to open the spinal canal and *divide the posterior nerve roots*. This is described on p. 130.

When operative interference is not possible or desirable, the surgeon must be content to relieve the pain by means of *anodynes*, such as injections of morphine or cocaine. When the compression is caused by

a malignant tumour, which before long will cause the patient's death, there need be no hesitation in resorting early and freely to the use of these remedies ; but when the cause of compression is a simple one and is not likely to destroy life, they should only be employed with great reluctance, on account of the risk of setting up a morphine or cocaine habit ; their use is only permissible when it is quite certain that the symptoms cannot be relieved by any form of operation. Hyoscine hydrobromide, in doses of $\frac{1}{120}$ to $\frac{1}{100}$ grain will often be very useful in alleviating the pain ; it should be injected locally as near as possible to the seat of the pain. As a preliminary to the more powerful anodynes, a trial may be made of antipyrine (5 to 20-grain doses), aspirin (5 to 15-grain doses), methylene blue (3 grains in pill), quinine (3 to 5-grain doses), Fowler's solution of arsenic (3-minim doses to begin with), or salicylate of soda (5 to 10-grain doses), either alone or in various combinations.

CONTUSION OR RUPTURE OF NERVES.

A nerve may be contused or ruptured by the sudden application of a force which either compresses it violently against a bone or else stretches it, so as to lead to partial or complete rupture. Actual rupture of a nerve is extremely difficult to produce ; usually the nerve is violently stretched, and some of the fibres are torn. The best examples of this are seen in the brachial plexus—the result of severe traction, *e.g.* the so-called birth palsies—or in attempting to save oneself by grasping at a projection during a fall from a height.

The changes which take place when a nerve is contused or stretched are rupture of some of the fibres, effusion of blood into the sheath (generally in the form of minute hæmorrhages), and rupture of the nutrient vessels, followed by disintegration of the nerve structures at the point of injury. These accidents usually occur as complications of fractures or dislocations ; sometimes they result from severe blows on the nerve as it runs over some bony prominence.

In the case of a motor nerve there will be paralysis of the muscles it supplies. In the case of a sensory nerve there will be complete loss of sensation when the injury is severe; when it is less severe, the patient usually complains of tingling and various perverted sensations. In either case neuritis is apt to supervene after a time.

TREATMENT.—The treatment is practically the same as that already described for compression of nerves (see p. 110). The same precautions must be taken to maintain the nutrition of the damaged nerve itself and the parts it supplies while waiting for recovery. When a considerable length of the nerve has been crushed into a pulp, and the continuity of nerve transmission completely destroyed, excision of

the irreparably damaged portion, followed by immediate union of the two healthy ends, is no doubt the best treatment (see p. 117). It is very difficult to diagnose this condition with certainty, because complete loss of function may result from a temporary and comparatively trifling injury; when several weeks elapse without any sign of recovery, however, and the loss of both sensation and motion is complete, the surgeon is justified in exposing the nerve opposite the seat of injury. Should it be found soft and pulpy, sufficient should be removed to allow healthy fibres to be made out above and below; the remaining steps of the operation are those for nerve suture (see p. 117).

Unless, however, the nerve has undergone complete destruction, there is no special advantage in excising the injured portion, because, while the nerve sheath remains intact and serves as a guide to direct the fibrils in the proper direction, the latter can spread down through the injured portion just as they will across the interval bridged over by operation. Hence, we only advise excision of a portion of the nerve when complete destruction has taken place.

WOUNDS OF NERVES.

Wounds of nerves may be simple punctures, clean-cut divisions, or lacerated wounds. It is, however, only necessary to discuss the treatment of a partial or complete division of the nerve, since a mere puncture does not usually call for special treatment. The changes that take place in a nerve after division, and the mode in which regeneration occurs, may be briefly summarised thus :—

Immediately after section of a nerve, the nerve fibres shrink up into the sheath, so that the stump of the nerve becomes covered with an irregular sheath of the connective tissue surrounding the nerve or perineurium, the whole forming a sort of bulbous ending. Degenerative changes set in at once, the myelinated sheath begins to break up, and, in the place of a continuous sheath, there appears a number of fatty droplets which are capable of taking the usual stains for fat. At the same time the essential part of the nerve, the axis cylinder, breaks up and finally disappears entirely. There remains the neurilemma or primitive sheath, and this soon shows indications of proliferative changes, the nuclei multiplying and assisting the leucocytes in the removal of the fat resulting from the disintegration of the myelinated sheath. On the side of the nerve between the section and the nerve cell these changes are very little marked, and only for a very short distance, but the nerve cell itself shows certain changes, chiefly fragmentation of the Nissl bodies, indicating that the section has also profoundly affected its nutrition.

The nerve which has undergone these changes may disappear

altogether, but there is usually a certain amount of resemblance to the normal nerve retained, the degenerated nerve persisting as a semi-translucent cord, smaller and flatter than it was before. If this be examined microscopically after the lapse of a few weeks it will be found to be composed of a fibrillar structure, along which fairly large nuclei are scattered at short intervals, the whole resembling a non-medullated nerve. The resemblance is, however, only superficial, for it is impossible to demonstrate any actual axis cylinders.

Regeneration commences from the central end of the nerve and progresses steadily towards the periphery. Although the axis-cylinders can grow for a considerable distance, they do not seem able to do so in indifferent tissues, at any rate for more than a short distance. For example, they cannot penetrate scar tissue, nor do they often find a new path for themselves through inter-muscular septa and subcutaneous tissue. A special track along which they can grow seems to be necessary, and the best is that provided by the degenerated peripheral portion of the nerve. When a portion of a nerve has been removed, a track has sometimes been provided, by the surgeon, by the introduction of foreign bodies (*vide infra*), but regeneration under these circumstances is far less certain than when the degenerated remains of the original nerve trunk are available.

TREATMENT.—In all cases *strict asepsis* is of the highest importance, both with the view of obviating the occurrence of neuritis, and also of minimising the amount of cicatricial tissue which must form between the divided ends, and which, if large, might lead to severe compression of the nerve trunk. Any foreign body present in the wound must be removed.

Of Partial Division.—When the nerve is only partially divided, the best plan is to bring the two edges of the wound in it into direct contact by means of fine catgut sutures introduced through the sheath. It may be tempting to leave the divided portion unsutured, and to hope that union will progress satisfactorily because a portion of the nerve remains intact. Unless the divided portions be brought into accurate contact and secured by sutures, however, the downward growth of new nerve fibrils, by means of which regeneration of function has to take place, is apt to be irregular, and the new nerve fibrils may miss the sheath of the distal portion owing to the curling up of the divided portion.

Of Complete Division.—When a nerve is completely divided, suture of the two ends is essential. The steps of the operation differ according to the period at which the operation is done, however, and we shall therefore discuss separately the treatment of recent cases and those of long standing.

Recent Cases.—When the nerve has been divided completely, the divided ends should be sutured together with as little delay as possible.

Hence, when a surgeon has to deal with a wound in the neighbourhood of important nerve trunks he should always see whether the functions of those nerves are impaired, for if nerve suture be required it should be done simultaneously with the treatment of the original wound, as the operation is then easier and more likely to be successful than if it be delayed until the wound has healed.

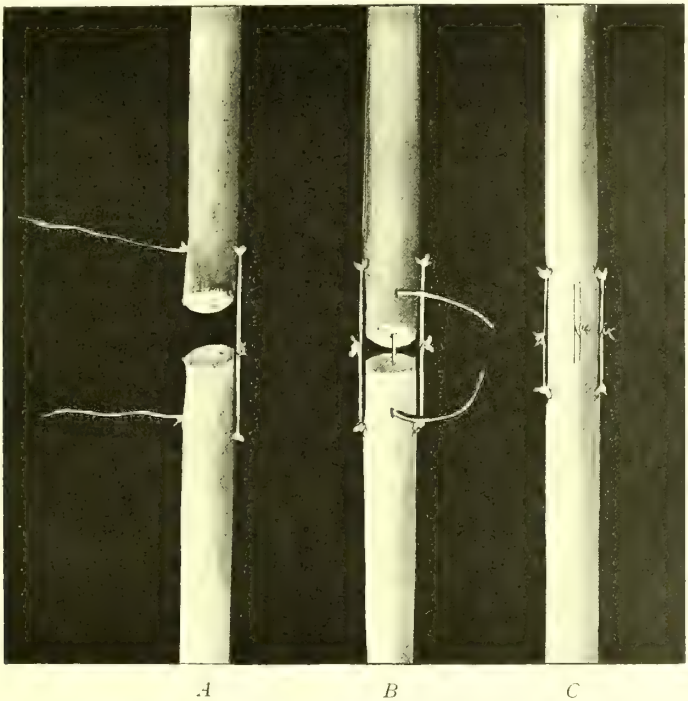


FIG. 38.—END-TO-END SUTURE OF A NERVE. The three stages of the procedure are shown in *A*, *B*, and *C* respectively.

Primary Nerve-suture.—The divided ends of the nerve are exposed in the wound and examined; if the cut surfaces be cleanly cut they may be sutured without any preliminary preparation, but if they be ragged it will be necessary to shave off a small portion on either side with a very sharp knife, so as to have the opposed surfaces quite smooth and sharply cut. The best material for approximation is the finest chromic catgut, on an ordinary round sewing needle;[1] the sharp edges of the triangular surgical needle are apt to divide the nerve fibrils.

[1] Only the finest size procurable must be used. If this be not at hand, the finest silk may be used. For the small nerves a very useful sewing material may be made by untwisting the three strands of which fine suture silk is made up and using one of them.

If the divided ends cannot be brought together without tension, as may be the case when a portion of the nerve has to be removed, the limb should be put into the position in which the cut surfaces come into accurate contact without any tension.

The sutures are inserted as follows: The needle is passed from before backwards through the whole thickness of the proximal portion of the nerve about its centre and at least a quarter of an inch from the cut surface; it is then passed through the distal portion from behind forwards in a similar manner. This stitch is tied so that it just brings the cut ends into accurate contact, without tension, otherwise it will cut its way through between the nerve fibrils. When this supporting stitch has been secured, three or four stitches are introduced around the periphery of the nerve, merely traversing its sheath so as to prevent lateral displacement of the cut ends (see Fig. 38).

After-treatment.—The wound is closed, a drainage tube being left in, if necessary, and the limb is fixed in a position that ensures the least possible tension upon the stitches. For instance, when a nerve has been divided on the front of the wrist, the fingers, the wrist, and the elbow should be kept in the fully flexed position by a suitably moulded posterior splint. This position should be maintained for about ten days, at the end of which time the skin stitches are taken out, and active and passive movements of the finger joints are begun, care being taken not to carry them so far as to pull upon the divided ends of the nerve; the flexion of the fingers and wrists may be somewhat relaxed. During the following week the fingers may be still further extended, and they may be left out of the splint so that the patient can move them for himself.

The splint may be left off in about six weeks, and massage and electricity employed. Recovery of function after division of a nerve is often slow, as long as two years often elapsing before it is complete.

Cases in which Cicatrisation of the Wound has taken place.—Here a considerable time must necessarily have elapsed since the occurrence of the injury, and the appropriate treatment is what is known as 'secondary nerve-suture,' in contradistinction to the method of 'primary nerve-suture' just described.

Secondary Nerve-suture.—The first part of the operation consists in finding and preparing the divided ends, a task which is not always easy. The dissection is facilitated if the part be rendered completely bloodless, and, therefore, when the operation is being performed upon one of the nerves of the extremities, an Esmarch's bandage should be applied higher up the limb (see Vol. I. p. 106), and should only be kept on until the nerve ends have been identified and isolated, in order that the oozing which commonly follows its application may have time to cease spontaneously

before the wound is sewn up. An incision is then made in the line of the nerve. The most satisfactory method for exposing the divided ends is to identify the sound nerve above the proximal end first. This can be done by means of the usual anatomical guides, and when the trunk has been thus identified, it is easily traced down until the bulbous divided end is reached. The identification of the distal portion is, however, more difficult. An attempt to expose the nerve below the point of section should first be made by using the ordinary anatomical guides, and this may be facilitated by pulling upon the proximal portion, which acts upon the distal end through the medium of the intervening fibrous tissue, and so leads to its identification. It is, however, a difficult matter to find the lower end when the nerve has been divided just before it splits up into a number of terminal branches, *e.g.* the median in front of the wrist.

After the nerve has been identified above and below the point of division, all the fibrous tissue between the two divided ends is dissected out cleanly. The bulbous end of the proximal portion must then be shaved away with a very sharp knife, until healthy nerve fibres are exposed; this need not imply complete removal of the bulb. The section must be kept strictly at right angles to the long axis of the nerve, and it is well to introduce some firm structure, such as a copper spatula, beneath it while making the section, in order to avoid tearing or bruising of the nerve. The upper end of the distal portion is next prepared by cutting off as much of the tapering end as is necessary to get a surface wide enough to suture to the proximal portion. There is no object in cutting off a large portion in order to look for healthy nerve fibres; the degeneration will have progressed a long way down, and any resection of the cut end only serves to increase the gap in the nerve and to make it more difficult to obtain proper approximation.

The method of uniting the divided ends will depend largely upon the amount of separation between them. This may be diminished to a great extent by grasping the proximal end of the nerve, and pulling gently upon it, so as to stretch it without rupturing any of the nerve fibres. In a long nerve, half an inch, or even more, may be gained in this manner without damaging it. If the divided ends now come into apposition fairly easily, they may be united by direct suture as described above (see p. 118).

Plastic Operations upon Nerves.—When the ends will not come into contact, in spite of nerve stretching and attention to the position of the limb, the surgeon has the choice of the following procedures:—

(1) The interval between the ends may be bridged with strands of fine catgut, which serve as a guide along which the new fibres can spread from the proximal to the distal portion.

(2) Both ends of the nerve may be enclosed in a tube of decalcified bone.

(3) Nerve-grafting may be employed. In this procedure a portion of nerve taken from one of the lower animals (heteroplastic transplantation), or from the amputated limb of another patient (homoplastic transplantation), is introduced between the two ends of the nerve, and fixed there by sutures. Sometimes the graft may be derived from a less important nerve in the patient himself, *e.g.* the internal saphenous (autoplastic transplantation).

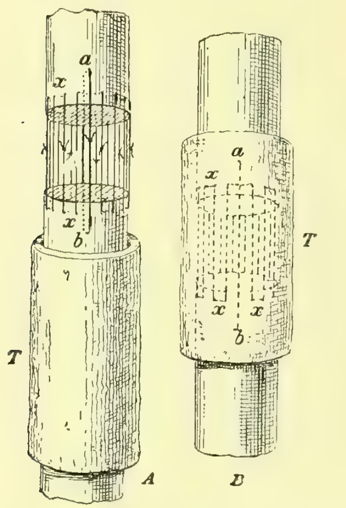


FIG. 39.—NERVE-SUTURE BY BRIDGING WITH CATGUT AND ENCLOSURE IN A DECALCIFIED BONE TUBE. In *A* is shown the first stage of the procedure. The bone tube *T* has been slipped over one end, well out of the way. A central fixation stitch *ab* has been inserted, and then all round the periphery of the nerve a series of fine catgut stitches *x* have been inserted through the nerve sheath. In *B* the bone tube is shown after it has been slipped into place over the ends.

(4) One or both of the divided ends of the nerve may be implanted into another nerve, which is intact (autoplastic grafting).

(5) In some cases, when the affection is in the extremities, the interval between the cut ends may be diminished by resecting portions of bones, and thereby shortening the limb and enabling the cut ends of the nerve to come into position.

The great desideratum in all these cases is a suitable guide along which the nerve fibres, developing from the upper portion of the nerve, may find their way down to the lower portion, and the object of all these plans, except the last two, is to provide this. In our opinion the best plan for cases in which the interval between the cut ends does not exceed two inches is a combination of the first two methods mentioned above; that is to say, the ends of the nerves are brought as closely together as possible, the interval between them is bridged by means of threads of catgut, and the whole of the defective portion is then surrounded by a tube of decalcified bone. This procedure has the great advantage that, while the decalcified bone tube provides a free and unimpeded channel, down which the new nerve fibres can spread, the threads of catgut ensure that the ends shall not be displaced should the bone tube become absorbed before the regenerated portion has reached the distal end.

The Combined Method of Bridging with Catgut and Enclosure in a Decalcified Bone Tube.—The technique of the operation is as follows: After the ends have been freed and pared and the parts relaxed as much as

possible, a decalcified bone tube of suitable size is slipped over one end of the nerve and pushed either upwards or downwards according to circumstances, so as to leave the cut end protruding for some little distance beyond the end of the tube. The divided ends are now sutured with fine catgut in much the manner described for primary nerve-suture (see p. 118). A round sewing needle is employed, one stitch is passed through the centre of the two portions of the nerve so as to steady them, and then a number of strands of catgut are passed through the sheaths of the two ends and tied. When the interval has been thus bridged over, the bone tube is slipped over the catgut and the nerve ends and left there (see Fig. 39). The wound is stitched up without a drainage tube, and the limb is put in a poroplastic splint moulded so as to relax the parts as much as possible. In ten days the skin sutures are taken out, and the limb may be gradually extended, the splint being finally left off at the end of six weeks. Massage, galvanism, and passive motion should then be employed either until the functions of the nerve are restored, or until it is obvious that no good results will accrue. In any case many months will elapse before the final result can be ascertained.

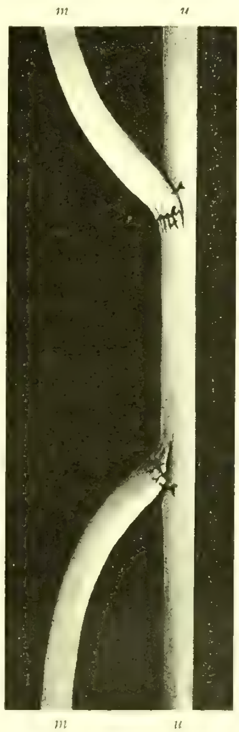


Fig. 40.—Nerve-grafting by double Lateral Implantation. The ends of the median (*m*) are refreshed and implanted laterally into the ulnar (*u*).

Fig. 41. Nerve-grafting by single Lateral Implantation. Here the proximal bulbous end of the median (*m*) is left untouched.

Nerve-grafting.—Grafting a portion of nerve from one of the lower animals into the gap between the divided ends is very uncertain in its results. The graft itself does not live; it merely acts as a connecting medium along which the new nerve fibres from the upper end are enabled to reach the distal portion.

Excision of Bone.—When the interval between the cut ends is more than two inches, and the condition of the part allows of it, a portion of the bone may be excised and the limb shortened so as to bring the divided ends of the nerve together. For instance, when a considerable portion of one of the nerves in the upper arm has been lost, a portion of the humerus can be excised so as to allow the nerve ends to come together. Preservation of the nerve function is of such importance that an operation of this kind should be done without hesitation in suitable cases. The divided ends of the bone are fastened together by one of the methods described in connection with fractures (see p. 305).

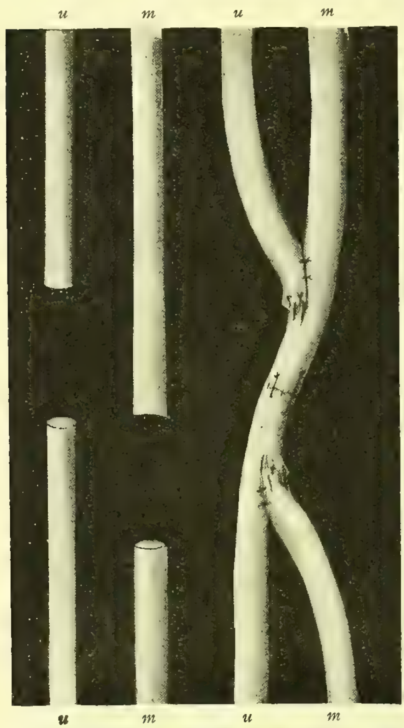


Fig. 42.—Nerve-grafting by Double Lateral Implantation. Here the four ends are refreshed and the proximal end of the median (*m*) is united end-to-end with the distal end of the ulnar (*u*). The proximal end of the ulnar and the distal end of the median are then implanted laterally into the single trunk thus formed.

Nerve Implantation.—The implantation of one nerve into another has been frequently performed with some success. The operation may be done in two ways. A case in which the median nerve has been divided and the ulnar nerve is intact may be taken as an illustration. In the first method the upper end of the median is refreshed, and implanted into the ulnar by making an incision through the sheath of the latter at one side so as to divide some of its fibres, inserting the end of the median into the opening thus made, and attaching the two nerves together by fine catgut sutures passed through their sheaths. The lower end is then refreshed and attached to the ulnar lower down (see Fig. 40). The principle of this method is that new nerve fibres will grow downwards within the sheath of the ulnar nerve, and reach and enter the lower end of the median again; or, failing this, that impulses will be conducted through the intervening portion of the ulnar, and will pass downwards along the distal portion of the divided median.

The second method is to attach only the distal end of the divided nerve to the sound one (see Fig. 41), by a lateral implantation similar to that just described. The object of this is to cause impulses passing down

the sound nerve to become diverted to the divided one, and thus to the muscles supplied by it. This method is used with some success in facial paralysis, in which the distal end of the paralysed facial is implanted into the side of the spinal accessory or the hypoglossal nerve.

In Fig. 42 is shown a more complicated method suitable for cases in which two parallel nerves, such as the median and ulnar have been divided at different levels, and neither can be sutured end-to-end. It is a combination of the end-to-end suture with lateral implantation.

Results.—The success likely to attend nerve-suture depends upon three main factors: firstly, accurate approximation of the divided ends; secondly, the length of nerve which has to be regenerated; and, thirdly, the condition of the muscles at the time regeneration occurs. The length of time which elapses between the division of the nerve and the performance of nerve-suture does not seem to matter to any great extent Restoration of function is often delayed for twelve months or even two years. Since the success of nerve-suture depends largely upon the condition of the muscles at the time when regeneration occurs, it is obviously important that the nutrition of the muscles should be maintained, as otherwise they may be so atrophied as to be incapable of work when regeneration of the nerve has taken place.

NEURITIS.

Neuritis or inflammation of nerve trunks may be acute or chronic. The acute form generally occurs in connection with a septic wound, or, more rarely, from some constitutional cause; in most cases neuritis is a chronic affection. The disease may be limited to a single nerve or branch of a nerve, a condition termed local or *peripheral neuritis*, or many nerves may be affected simultaneously, a condition known as *multiple neuritis*. The surgeon has only to deal with the peripheral form, which may be due to either a local or a general cause.

CAUSES.—(*a*) **Local.**—Neuritis may occur in connection with *a wound*, particularly when this is septic. When it follows *an injury* it is most frequently due to incomplete division, or to laceration or contusion of a nerve, rather than to complete division by a clean cut. The presence of *a foreign body* in a wound frequently sets up neuritis, or aggravates the condition, should it have already occurred as a result of sepsis. The disease may also be caused by *extension of inflammation* from some focus in the neighbourhood. For example, in tuberculous spinal disease the inflammatory process may extend to the nerves as they emerge from the inter-vertebral foramina, or it may follow such an affection as a carious tooth, in which case the inflammation spreads up the nerve and reaches several of its branches. One of the most common local causes of neuritis is *pressure*; a marked example of this is seen when an aneurysm presses upon some of the large nerve trunks; the pressure of new growths acts

in a similar manner. *Exposure to cold* is a common cause of neuritis (Vol. I. p. 180); the indolence of the ulcers that follow upon a mild degree of frost-bite has been attributed by some authorities to neuritis set up by the action of the cold.

(*b*) **General.**—Among these may be mentioned alcoholism, syphilis, gout, diabetes, rheumatism, and anæmia. Neuritis due to a constitutional cause is apt to be multiple.

PATHOLOGICAL CHANGES.—In acute neuritis the nerve becomes distended, and softened, and its vessels are engorged; extravasation takes place into the nerve, followed by degeneration of the nerve fibres. In the more chronic cases the changes are those characteristic of chronic inflammation. The nerve becomes enlarged and harder than usual; under the microscope proliferation of the nerve sheath and formation of new fibrous tissue are seen. As it contracts, this new fibrous tissue presses upon the fibres, and causes them to atrophy.

SYMPTOMS.—The nerve functions soon become impaired; in severe cases the parts supplied may permanently lose both sensation and motion, but such cases are exceptionally rare. In sensory or mixed nerves the earliest effect of the inflammation is neuralgic pain, which is accompanied by hyperæsthesia of the skin supplied by the nerve; in some rare cases epileptiform convulsions may occur as an early symptom. The neuralgic pains are at first limited to the affected nerve and its branches, but in the later stages of the affection they may spread to nerves other than that primarily affected. For example, the pain in neuralgia in one division of the trigeminal nerve is very apt to spread to the other divisions, and may even affect the corresponding nerves on the opposite side.

Accompanying the hyperæsthesia are usually perversions of sensation, such as tinglings; these are generally worse at night. Tenderness is often present over the spots at which the nerve pierces the deep fascia. It is also common for trophic changes to be met with in the part supplied by the affected nerve. The temperature of the limb may be considerably raised at first, whilst the cutaneous circulation is increased and the limb looks flushed and hot. Various skin eruptions, such as bullæ followed by indolent ulcers, may also occur, whilst the nails become rough and corrugated. After a time sensation becomes less acute, and anæsthesia may gradually increase until it becomes complete. The muscles supplied by the motor fibres waste, but complete paralysis rarely occurs. Paresis generally affects only two or three of the muscles supplied by the nerve, and is seldom present except when the inflammatory process has been very acute, or has lasted so long as to disorganise the affected nerve completely.

An established neuritis has a great tendency to extend along the nerve in both directions; that is to say, it may ascend from the branches to the trunk or *vice versâ*. Thus a condition that was at first a local or peripheral neuritis may develop into the more diffuse or multiple variety.

In bad cases the affection may ascend to the spinal cord, and in the severer forms a myelitis may actually be set up.

Diagnosis of Neuritis from Neuralgia.—Neuritis is often accompanied by neuralgia, but the latter may occur apart from neuritis. These affections are very apt to be confounded—a matter of primary importance since the treatment differs considerably in the two cases. In neuralgia the pain is intermittent, whilst in neuritis it is continuous ; in neuralgia there is no tenderness along the course of the nerve, while this is almost invariably found when the nerve is inflamed. In neuralgia there is no local elevation of temperature, no spasm of the muscles supplied by the nerve, and no paralysis ; and lastly the trophic lesions above described do not occur.

TREATMENT.—**Prophylactic treatment** is of great importance in wounds in the neighbourhood of large nerve trunks, particularly when the latter have been divided or lacerated. The risk of neuritis in these cases must be borne in mind, and care taken to prevent it.

The first point is to *see that the wound is kept aseptic*, because neuritis is more frequent in septic than in aseptic wounds. Hence, scrupulous care should be taken to disinfect all wounds involving or occurring in the neighbourhood of important nerves. Search should also be made for any *foreign body* which may be lying in contact with the nerve.

When a nerve has been divided in a wound, it is important to *see that its ends are not left projecting* upon the surface, or in any position in which they may become involved in the scar. Hence in amputation wounds it is the rule to pull out the large nerves with forceps, and cut them short, so that they shall be divided at a considerably higher level than the muscles and other structures. When a nerve has been torn across, it is well to *cut off the lacerated portion*, and then to bring the divided ends of the nerve together and suture them if possible.

When neuritis is established the most important point is to *search for the cause* and remove it, if possible. This may be local or general, and it must be remembered that a neuritis set up by a local cause may sometimes be much aggravated by the general constitutional conditions already referred to. Any local cause must, therefore, be searched for first. Should the neuritis be due to an area of inflammation in the vicinity of the nerve, such as a carious tooth, this should be removed, or treated so as to get rid of the irritation as quickly as possible. Should the neuritis occur in connection with a cicatrix, the scar must be excised ; should it occur in connection with amputation flaps, a fresh amputation must be performed higher up, or the flaps opened up, and the ends of the nerves freed from the scar and cut short, so as to avoid the possibility of their implication a second time. In addition, any constitutional causes should be treated ; if the patient be alcoholic, the alcohol should be cut off ; should there be a rheumatic tendency, treatment by salicylate of soda or salicin should be adopted ; while, if the patient be

gouty, a course of colchicum and iodide of potassium should be administered and the diet suitably regulated. In syphilitic cases much good may be done by the appropriate treatment for the particular stage of that disease (see Vol. I. Chap. XI.). The general health should be attended to in all cases. If there be anæmia, the administration of iron and arsenic will often give great relief to the pain; quinine is also a valuable drug.

In acute neuritis a mercurial or saline *purge* should be administered, calomel being the best for the purpose. The patient should be *confined to bed* if the neuritis affect the lower extremity, or to a warm room if it be situated elsewhere. Should there be a *septic wound*, this should be properly drained (see Vol. I. p. 165). *Hot fomentations* over the nerve are often of value, and a few drops of tincture of belladonna may be added to them with advantage; their action may be enhanced by applying an india-rubber hot-water bottle outside them. The frequent use of hot *baths, or douches*, or a Turkish bath is often followed by considerable relief. If a Turkish bath be employed, however, it must be one of the small portable baths that can be used in the patient's own room; anyone suffering from acute neuritis ought not to go out of doors for the purpose of taking a bath, because of the risk of catching cold afterwards and aggravating the affection. Superheated air or radiant heat often gives good results, particularly when the neuritis affects the upper extremity.

Local blood-letting by leeches applied along the course of the nerve should be used when the fomentations do not give sufficiently prompt relief; the hot fomentations should be continued afterwards. When the pain is very acute, it will be necessary to have resort to anodynes, and those on which the chief reliance is to be placed are morphine and cocaine or β-eucaine *Cocaine* is the most certain of these drugs; it should be injected hypodermically in doses of about a sixth of a grain as a 2 per cent. solution as near the seat of pain as possible, or along the course of the nerve higher up, not all at one spot, but a drop or two at a time, into the tissues around the nerve. It acts locally upon the nerve affected, and thus often produces immediate, though temporary, relief; β-eucaine may also be used in somewhat larger doses ($\frac{1}{4}$ to $\frac{1}{3}$ grain). When the pain is very severe, and the affection comparatively widespread, it may be necessary to have recourse to subcutaneous injections of *morphine*, and these are likely to be more certain and more lasting in their effect than cocaine. Great care, however, must always be taken in employing remedies of this kind to avoid setting up a morphine or cocaine habit; nothing is worse than to allow a patient to practise the injection for himself, or to have the drug injected whenever he desires it. *Phenacetin and antipyrin*, in 5 to 10-grain doses every four hours, are also of use in some cases. *Exalgin* in 2 to 3-grain doses is especially useful in neuritis affecting the face or head. Apart from this necessity for relieving the

acute pain, the treatment is similar to that for other forms of acute inflammation (see Vol. I. Chap. I.).

In chronic neuritis, which either follows an acute attack or has been chronic from the first, the treatment consists partly in the employment of *constitutional remedies*, according to the diathesis of the patient—a point already dwelt upon on p. 125—and partly in the employment of *local measures* which principally take the form of counter-irritation, followed by massage, friction, and galvanism, as the case improves. The best form of *counter-irritation* is a blister or the actual cautery (Corrigan's) applied over the course of the nerve. If a blister be employed, it should be long and narrow, and should be applied with its long axis corresponding to that of the nerve. It should be repeated once a week if necessary, and it is well to prolong the effect by the application of savin or resin ointment to the blistered surface (see Vol. I. p. 20). *Galvanism* is also of considerable value in the more chronic cases. It is best to employ an ascending current, that is to say, the negative pole of the battery is applied to the spine whilst the positive electrode is placed over the nerve ; no interruptions should be made in the circuit. The current should be very weak at first and should be increased very gradually ; if it aggravate the pain, it should be discontinued. When benefit follows its employment, it may be applied daily for half an hour at a time, its strength being gradually increased. Injections of alcohol into the substance of the nerve or into the tissues in its immediate vicinity are a good deal employed at the present time. These are most often used for trigeminal neuralgia and will be described more fully in connection with that affection (see Vol. III.).

After the pain has disappeared, *massage* should be employed, and this may also with advantage be carried out in the direction of the affected nerve trunk. A good way of carrying out the treatment is to order the patient to take frequent baths as hot as he can bear, and immediately afterwards to have the limb vigorously massaged and wrapped up in flannel or cotton wool, after which he rests in bed or upon the sofa for some time. Anodyne liniments are useful when the pain is severe, and they should always be resorted to in preference to morphine or cocaine as long as they influence the pain. The best of these are linimentum belladonnæ, linimentum terebinth. aceticum, or the following liniment :—

℞	Menthol	ʒj.
	Liniment. camph. co. } Liniment. belladonnæ } . .	āā ℥ss.

They should be used after a hot bath at night, as the pain is apt to increase when the patient goes to bed.

The constitutional treatment must be attended to in all cases. Quinine, strychnine, iron and arsenic are of great value, and at the same time the patient must be under the best hygienic conditions ; any constitutional

condition which may have any bearing upon the affection should receive appropriate treatment.

Operative Treatment.—Should these palliative measures fail, the question of operative interference will arise. Palliative measures should be abandoned in favour of operative procedures, if the symptoms indicate that the neuritis is spreading in spite of careful treatment. The operative measures suitable for neuritis are: (1) acupuncture; (2) nerve-stretching; (3) neurotomy; and (4) neurectomy.

Acupuncture.—At one time the plan of puncturing an inflamed nerve with a long needle was much in vogue, especially in cases of sciatica. The patient is not anæsthetised. The position of the nerve is first marked out, partly by anatomical data and partly by the pain experienced on pressure. A long round needle is then thrust rapidly through the skin down into the nerve. The only way of performing this operation successfully is to use a very sharp needle and to plunge it rapidly through the soft parts, as otherwise the point of the needle glances off the nerve and does not penetrate it. After the first needle has been introduced, it is left *in situ* so as to fix the nerve, along the course of which some six or eight needles are then introduced at other points. A good guide as to whether the nerve has been punctured or not is the pain experienced by the patient. The pain on puncturing a nerve is sharp and characteristic and is referred to the particular nerve itself, whereas there is no special pain attached to a puncture rapidly performed through the soft parts; if, therefore, any of the needles fail to elicit this characteristic symptom, they should be removed and reintroduced. The mode in which this procedure acts is difficult to understand, but it undoubtedly gives relief in some cases, and as it is harmless, it might precede the performance of such an operation as nerve-stretching in the case of a large nerve like the sciatic.

Nerve-stretching.—Nerve-stretching has been much employed in cases of obstinate sciatica. Its results vary considerably, but in some cases the benefit is most marked. The precise manner in which the effect is produced is by no means clear, but in part the explanation may be that the new fibrous tissue, forming in the nerve in consequence of the inflammation, which exerts injurious pressure upon the nerve fibrils, is torn through, and thus the pressure upon the nervous elements is relieved. Nerve-stretching also produces some alteration in the transmission of the nerve currents, and thus leads to temporary diminution in the transmission of sensory impulses and considerable relief of the pain that is a constant accompaniment of the affection. In the majority of bad cases the immediate effect of properly performed nerve-stretching is very marked; the pain may disappear entirely, and is almost invariably much improved, while for a time at least the patient may be apparently well. In some cases this improvement is permanent and a cure results; in the majority, unfortunately, there is apt to be recurrence, which is

probably due to extension of the inflammation and the formation of fresh adhesions in and around the nerve.

The nerve is exposed by an incision immediately over its course, freed from the surrounding parts and stretched. In a large nerve this is generally performed by the fingers; in a smaller one by introducing beneath it a blunt hook, upon which the nerve is lifted and traction thus exerted.

The exact amount of force that it is advisable to employ, so as to stretch a nerve effectually without damaging it, will vary of course with the particular nerve operated upon. In the case of the sciatic, the limb

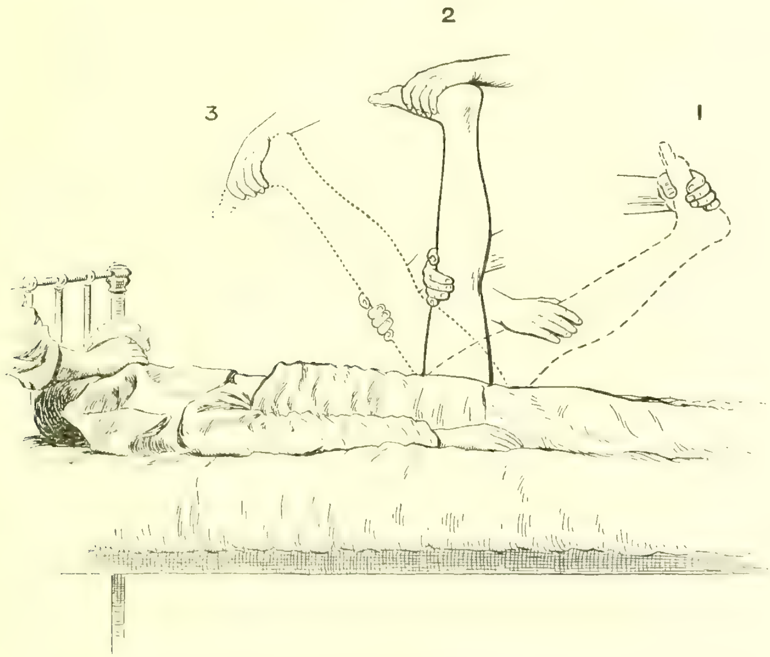


Fig. 43.—Stretching the Great Sciatic Nerve without Operation. The toes should be dorsi-flexed to the utmost and the knee kept fully extended while the hip is being flexed. The figures represent the stages in the stretching.

may be raised from the table by pulling upon the nerve without fear of doing any damage. The traction should be steady, and should be made in both directions, the peripheral end of the nerve being first pulled upon and afterwards the central; rather less force should be employed in the latter direction. It is common to feel bands of fibrous tissue giving way as the stretching is carried out, and at the end of the operation the nerve will often be found a good deal increased in length, so that it lies loose and flaccid in the wound (see Figs. 52 and 53).

After the nerve has been stretched, it is replaced in the wound, which is sewn up without a drainage tube. Special care must be taken to avoid

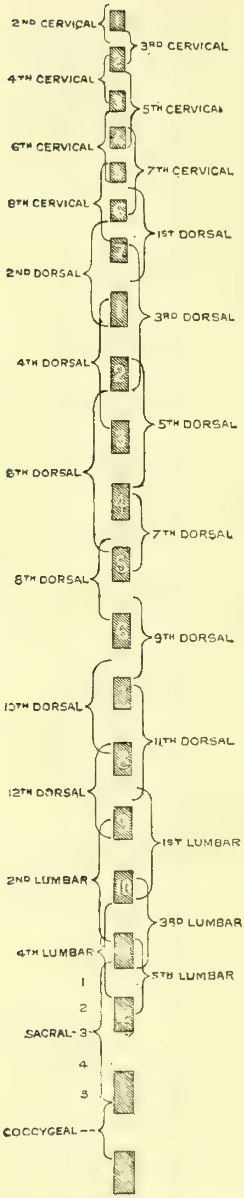


FIG. 44.—DIAGRAM ILLUSTRATING THE RELATION OF THE SPINAL NERVE ROOTS TO THE SPINOUS PROCESSES. The figure shows which spinous processes and laminæ must be removed in order to expose any particular nerve root. (Quain's *Anatomy*.)

septic infection, as this would aggravate the neuritis already present. The usual effect of the operation is to produce a temporary paralysis of the parts supplied by the nerve, which is generally partial, but which may be complete. This is often accompanied by perversion of sensation, which gradually passes off as the function of the nerve becomes restored. After the wound has healed, friction, massage, and counter-irritation should be employed.

Nerve stretching without exposure of the nerve.—In the case of sciatic, this may be done by flexing the thigh to a right angle, whilst the knee is kept fully extended (see Fig. 43). A general anæsthetic should be administered.

Neurotomy. — When nerve-stretching has been employed in vain for neuritis of a sensory nerve from which the patient is suffering great agony, some further operative interference becomes necessary; this generally takes the form of neurotomy or neurectomy. It is essential for the success of either of these operations that the portion of nerve divided or excised should be well above the seat of the inflammation, as otherwise the affection spreads upwards in spite of it. The nerve should be exposed as near its central origin as possible before it is divided. Neurectomy is much more likely to be efficient than neurotomy; when the latter is employed, the transmission of impulses is often restored rapidly, and the relief given by the operation is only temporary.

Neurectomy.—We are therefore forced to the conclusion that the best practice is to perform neurectomy when it is possible, and to excise a large portion of the nerve—two inches or more—so as to prevent the transmission of impulses along it. The operation should be confined to purely sensory nerves, except in cases of inoperable malignant tumours, where loss of motion is of no consequence.

Excision of the Posterior Nerve Roots.—When a sensory nerve cannot be exposed above the inflammatory area, the question of the removal of the posterior nerve roots of the

affected trunk must be entertained. If this procedure is to be adopted at all, it should not be too long delayed, as otherwise the neuritis will have extended so far upwards as to have actually reached the spinal cord, and the patient will then be only imperfectly relieved by operation. Unfortunately, this operation does not appear to have been attended with much permanent success when performed for the relief of pain due to neuritis. It has, however, been attended with better results when performed for the gastric crises and lightning pains of tabes, and good results have also followed when it has been done in certain cases of spastic paraplegia (see Förster & Hey Groves, *Lancet*, July 8, 1911). In order to do this, laminectomy must be performed, and the spinal dura mater divided ; the particular nerve roots can then be cut close to their origin from the cord. As the operation usually involves considerable shock, all the prophylactic measures recommended in Vol. I. p. 117 should be carried out. Braun (*Deutsch. Zeitscrft. für Chir.*, 1910, p. 561), quoted by Hey Groves (*Lancet*, 1911, ii. p. 84), injects 2–3 ounces of a 1 in 50,000 solution of adrenalin into the subcutaneous and muscular tissues and obtains thereby an almost bloodless operation with very little shock.

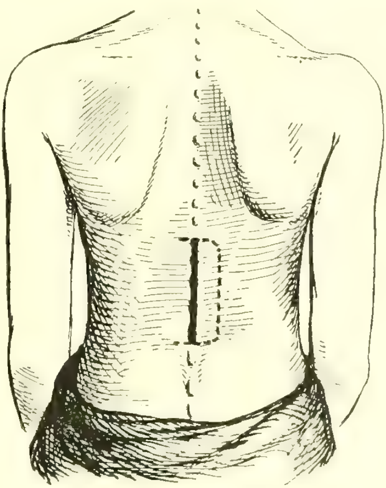


Fig. 45.—Incisions for Laminectomy. The merits of the two forms are discussed in the text.

The operation of *laminectomy* is done as follows: The patient is turned over upon the face, and the spinous processes of the vertebræ are carefully counted, and those which require removal are noted. In order to avoid mistakes in the latter part of the operation, these processes may be marked out by driving a needle or some similar instrument into one of them, so as to act as a guide for identification later on. Reference to Fig. 44 will show the relations of the root origins of the spinal nerves to the spinous processes of the vertebræ.

Incision.—The skin incision must be very free, since the laminæ lie deep down, and the parts must be widely retracted before they can be satisfactorily exposed ; when, for example, the laminæ of two or three vertebræ are to be removed, the incision should at any rate reach from a couple of spines higher up to a couple of spines lower down than the area to be operated upon. Some surgeons employ a median incision, while others use a curved one ; the latter has the advantage, that it removes the scar from the line of the spinous processes. The advantage of the vertical incision is that it can be enlarged when necessary, and, if

the patient be very muscular or fat, a small transverse incision may be made at each end of it. The curved incision may have its convexity either upwards, downwards, or to one side; on the whole, a lateral flap is best. The convexity of the curve extends to one side as far as the outer edge of the spinal muscles, and crosses the middle line both at the upper and lower ends (see Fig. 45).

Retraction of the Muscles.—The next point is the separation of the muscles from the spinous processes and the laminæ. This should be effected as rapidly as possible. Any spouting vessel should be clamped and a sponge wrung out of hot saline solution (about 110° to 120° F.) should be packed into the vertebral groove on one side, while the muscles on the opposite side are being separated, and in a very short time the oozing stops. The muscles are divided at their attachment to the spinous processes and are then rapidly stripped off with a curved raspatory as far out as the transverse processes; they are pulled firmly aside by large flat retractors.

Removal of the Spinous Processes.—When the neural arches have been thoroughly cleared, the spinous processes are removed. This is done by nipping through their bases with a pair of angular cutting pliers (see Fig. 46); it is generally well to remove the spinous process both of the vertebra above and that below the ones to be operated upon, in order to gain proper access to the laminæ. After retracting the soft parts forcibly, the spinous processes should be identified again, so as to avoid the possibility of dividing the wrong nerves.

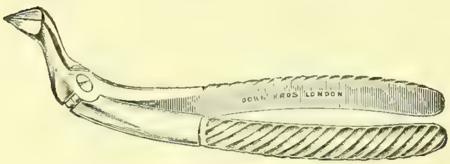


FIG. 46.—LAMINECTOMY PLIERS.

Removal of the Laminæ.—The spinal canal is now opened by removing the laminæ. Taylor (see Hey Groves, *loc. cit.*) suggests a hemi-laminectomy when the affection is one-sided and, according to Hey Groves, this is an excellent plan in the cervical region. In the lumbar region, however, a complete laminectomy is necessary owing to want of room. Here there is a choice between two procedures: in the one the laminæ are completely removed; in the other, they are detached, lifted up upon a hinge and subsequently replaced in position. The latter method is called osteo-plastic resection and is theoretically the better, because after the operation the bony covering to the cord is restored, and adhesion between the cicatrix and the dura mater is avoided; but it prolongs the operation considerably, adds to the shock, and is not always easy to perform. We shall describe both methods, but the osteo-plastic form will probably be rarely used. The great difficulty in either case is the removal of the first lamina, because it is essential to avoid injuring the cord in the process. It may be done in various ways.

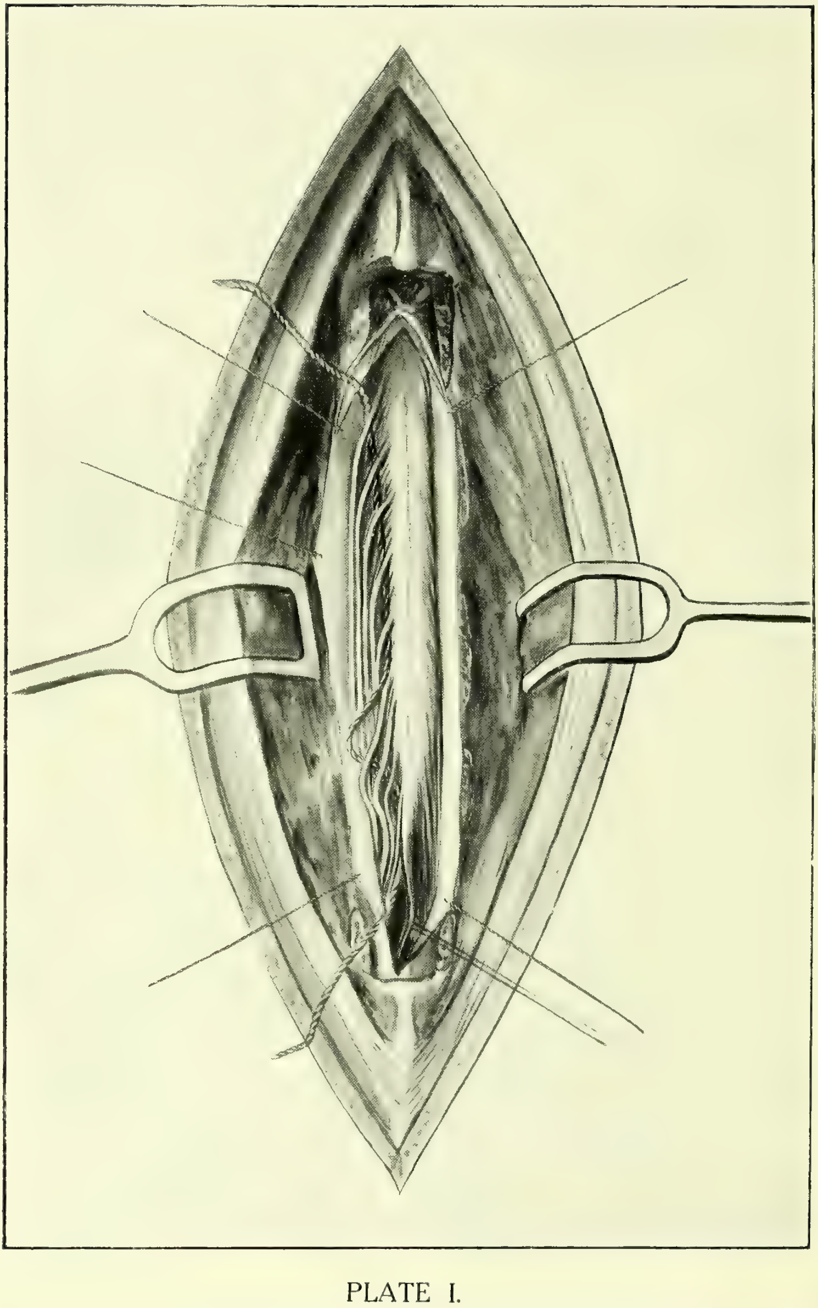


PLATE I.

COMPLETE LAMINECTOMY IN THE DORSO-LUMBAR REGION.

The laminæ of the 11th and 12th dorsal and 1st and 2nd lumbar vertebræ have been completely removed. The theca has been opened and a thread passed behind the posterior nerve roots. The highest root shown is the 1st lumbar, the lowest the 4th sacral. The filum terminale is held up by a thread. (*Hey Groves.*)

[This and the following Plate have been drawn, by kind permission of Mr. Hey Groves, from the photographs illustrating his paper in the *Lancet* quoted in the text.]

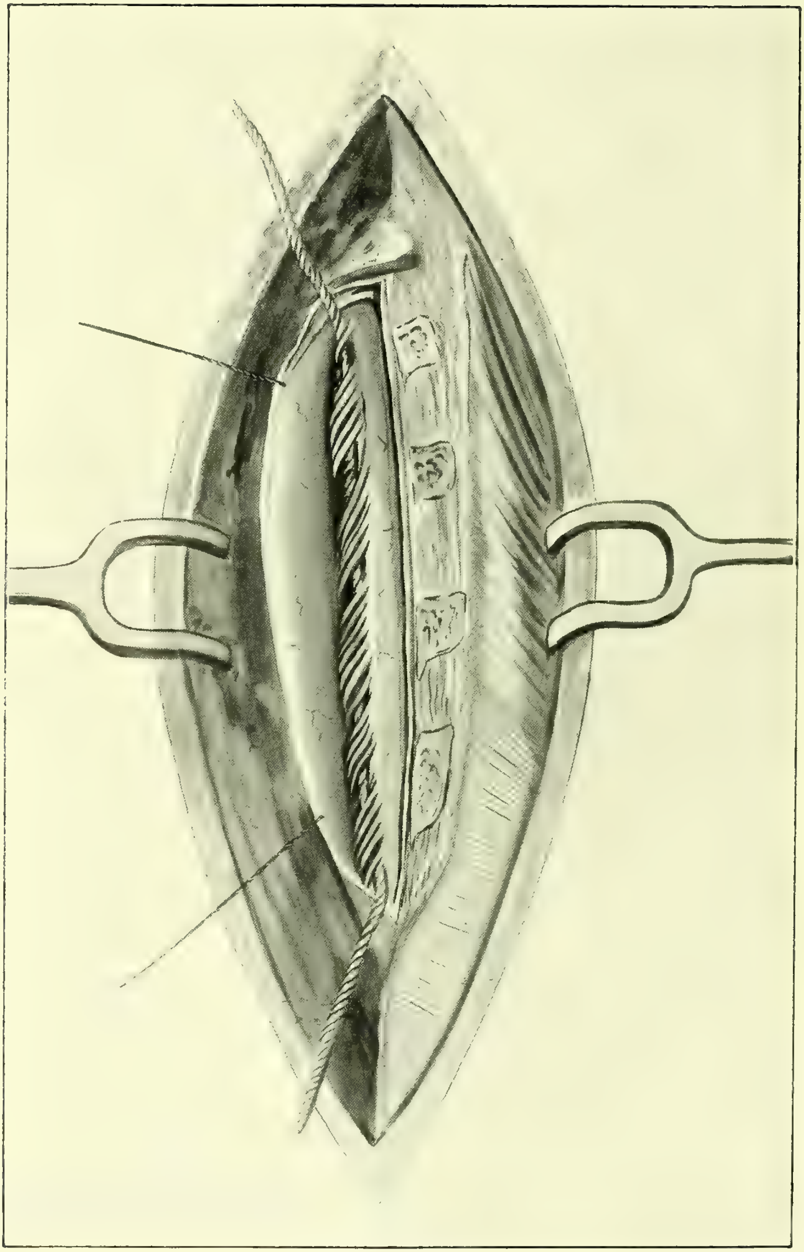


PLATE II.

HEMI-LAMINECTOMY IN THE CERVICAL REGION.

The laminæ of the 5th—7th cervical vertebræ have been removed on the left side only. A thread lies behind the posterior nerve roots. The highest root shown is the 5th cervical, the lowest the 2nd dorsal. (*Hey Groves.*)

If the laminæ are to be completely removed, it is simplest to apply a small trephine (one inch crown) over the root of the spinous process (see Fig. 47)—it is immaterial which, but generally the one at the upper or lower limit of the incision is selected—and a circle of bone is carefully cut out. This opens the neural canal and then it is easy to cut through the laminæ on one or both sides as far out as possible with cutting pliers, guarding the dura from injury, meanwhile, by a suitable spatula. When the section of the bone is complete, the lamina is removed by dividing the ligaments connecting it with those immediately above and below it. A more tedious and, perhaps, more dangerous plan is to apply a laminectomy saw (see Fig. 48) close to the junction of the lamina with the pedicle on each side and to saw it partially through, when the division is completed either with a chisel or with cutting pliers. At the root of the spinous processes the dura is separated from the bone by a greater interval than elsewhere, and therefore there is less likelihood of it being damaged. Moreover, by sawing the laminæ in the position just mentioned, it is easy to pass too far outwards and miss opening the spinal canal. When the first lamina has been removed, it is easy to insinuate the blade of the cutting pliers beneath the next above it, and so to divide it ; the laminæ are lifted out as they are freed. In the cervical region the laminæ on the affected side only will be removed (see Plate II.).

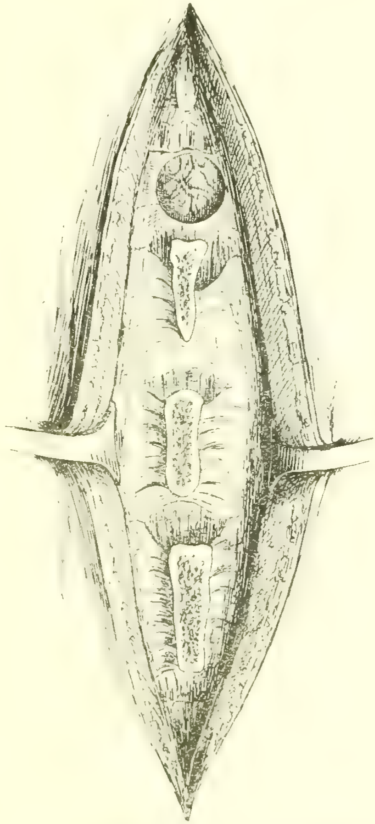


FIG. 47.—REMOVAL OF THE LAMINÆ IN LAMINECTOMY. The spinous processes have been clipped off with the pliers, and the opening into the spinal canal is made by means of the trephine hole seen on the uppermost neural arch. The opening is then easily enlarged, until the entire lamina is removed.

Should it be decided to retain the laminæ, they may be turned back in one piece, after the removal of the spinous processes and opening the spinal canal as in the former method by carefully dividing the requisite number of laminæ on each side by a laminectomy saw, aided by cutting pliers, and then dividing the ligaments connecting the lowest lamina of the block with the one below it, and turning up the laminæ in one mass on a hinge which is formed by the ligaments connecting the uppermost

lamina divided with the one immediately above it (see Fig. 49). In order to facilitate the turning back of the laminæ, it is well to cut away the spinous process of the vertebra immediately above the uppermost of the detached laminæ.

Opening the Dura.—After the vertebral canal has been opened, a quantity of fat containing a large plexus of veins is found lying immediately over the dura mater. This should be carefully opened in the middle line with as little damage to the veins as possible and slit up throughout the whole extent of the wound, with fine scissors; the edges may be held apart either by toothed forceps, or by silk sutures passed through them (see Plate I.). Care should be taken to prevent the escape of the

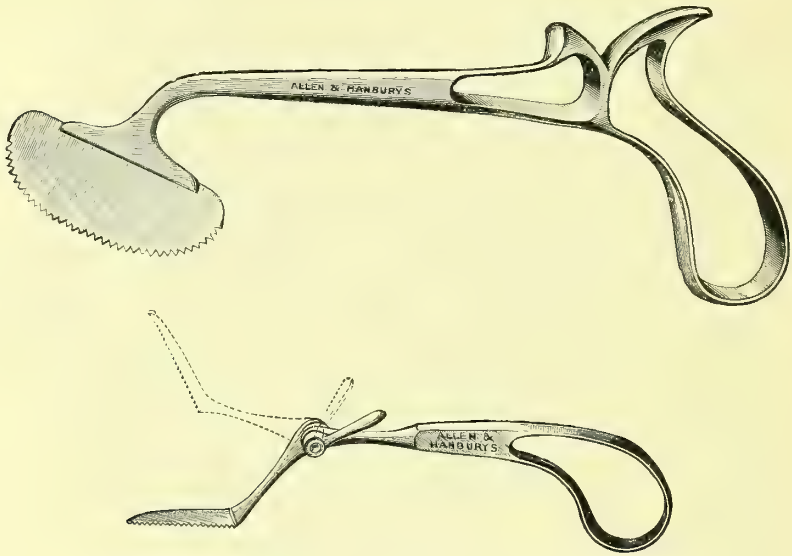


Fig. 48.—Laminectomy Saws. The lower one has a fine blade adjustable at any angle and is very useful for work in the lumbar region.

cerebro-spinal fluid in any quantity by keeping the head hanging down, in order to allow the cerebro-spinal fluid to collect in the skull.

The nerve roots that are to be resected, having been identified, are divided close to the spinal cord, turned outwards, and as much as possible removed. Great care must be taken to avoid injuring the anterior roots, which would entail motor paralysis. All bleeding is arrested, and the incision in the dura mater is closed completely by fine catgut sutures. If the laminæ have been turned back they are replaced, and the skin wound is sutured. There is no need to fasten the laminæ in place by sutures or other contrivances.

After-treatment.—A large mass of dressing is put on after the wound has been sewn up, and a large moulded shield of poroplastic

material or plaster of Paris is fitted to the back and sides of the trunk to ensure immobility. Unless the dressing becomes soaked with discharge, it need not be changed for ten days, when the stitches are taken out.

NEURALGIA.

Neuralgia is a condition characterised by lancinating pain along the course of a nerve without any coexisting pathological change in the nerve itself, although there may be changes in the corresponding ganglion. The affection often begins in connection with inflammation or the presence of a foreign body in the neighbourhood of the nerve, or from direct pressure upon some portion of it. The condition differs from neuritis, inasmuch as there is an inflammatory change in the structure of the nerve in the latter disease, whilst in neuralgia there are no pathological changes to be found in the nerve. The affection is common in anæmic and debilitated subjects, and is frequently met with in those who are neurotic. It is also said to be due to malaria, over-exertion, shock, exposure to cold, etc.

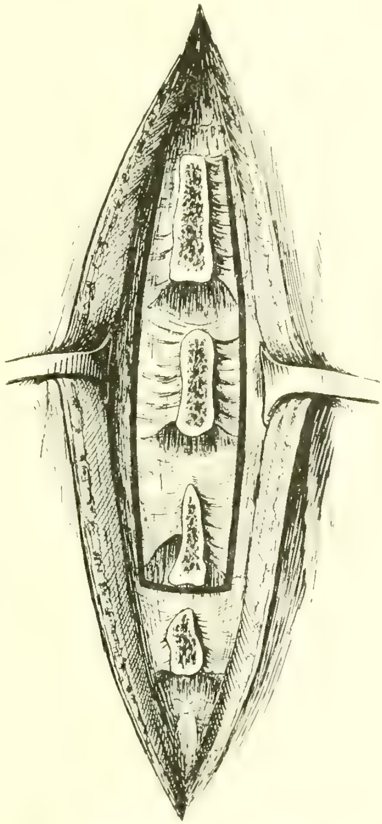


FIG. 49.—METHOD OF RETAINING THE LAMINÆ IN LAMINECTOMY. The thick black lines show (semi-diagrammatically) the incisions necessary to turn up the block of three laminæ. The incisions through the bones are made partly with a saw and partly with a chisel, while the ligaments are divided with probe-pointed scissors.

The symptoms consist mainly of paroxysmal attacks of pain of great severity, which start from one point in the distribution of the nerve and extend along its course; in the intervals there may be entire absence of pain. As a rule there is no pain on pressure over the course of the nerve except at the points where the nerve passes through an opening in fascia or bone. The pain often interferes with sleep, and in this way the patient's general nutrition is impaired, but there are no trophic changes.

TREATMENT.—The treatment of neuralgia belongs, in the first instance, essentially to the physician; but when medical remedies fail, the surgeon is not infrequently called in.

Medical Treatment.—The most important *drugs* are arsenic in increasing doses, iron, quinine, strychnine, etc. At the same time any

constitutional tendency such as gout will require treatment with colchicum and other appropriate remedies ; rheumatism, with salicin or salicylate of soda ; and the treatment for syphilis (see Vol. I. Chap. XI.) will be called for when there is a syphilitic history. For the relief of the pain various *external remedies* will be required, of which the most important are the anodyne liniments, especially belladonna ; menthol and aconite are also of use.

Another method of relieving the pain is by the hypodermic administration of such drugs as atropine, cocaine, and morphine. A weak galvanic current may be used daily, and often gives considerable relief. The positive pole should be applied near the seat of the pain, whilst the negative is connected with a large, flat, moist electrode placed over the spine. The current should be passed for 15 minutes at a time ; it should be sufficiently weak not to cause any pain, and should be very cautiously increased in strength ; no interruptions should be employed in the circuit. *Alcohol* has been injected into or around the nerve with success in bad cases. This is usually done for trigeminal neuralgia and is described fully in connection with that affection (see Vol. IV.).

Operative Treatment.—Of the surgical operations that have already been described in the treatment of neuritis, there are only two applicable to cases of neuralgia : these are *neurotomy* and *neurectomy*, the latter of which is preferable. The portion of nerve excised should be as far away from the seat of the pain as possible ; indeed, in some cases, it is advisable to perform the operation in the immediate neighbourhood of the central origin of the nerve, as, for example, removal of the Gasserian ganglion for trigeminal neuralgia (see Vol. IV.).

CONVULSIVE TIC.

Another nerve affection, which is considered in detail in connection with the affections of the head and neck (see Vol. IV.), is that in which intermittent muscular spasms occur as a result of an affection of the nerves. This condition is spoken of as convulsive tic, and consists of intermittent and involuntary contraction of various muscles or groups, particularly in the facial and cervical regions.

The surgical treatment of this condition will be either *nerve-stretching* (which is only likely to succeed in the milder cases) or *neurectomy*, which may cure the disease if practised sufficiently early and freely.

TUMOURS.

NEUROMATA.

The ordinary tumours of nerves are spoken of as neuromata, but, as a rule, they are not strictly neuromata, that is to say, they do not consist of true nerve tissue. The ordinary neuroma is usually of the connective

tissue type, being either fibromatous or myxomatous in structure ; these tumours usually commence in connection with the connective tissue of the nerve sheath, and may be entirely outside the nerve, or may occur between the nerve bundles. They give rise to neuritis and neuralgic pain, which is sometimes insupportable. Later on, the pressure they exert may cause paralysis both of motion and sensation if they occur in a mixed nerve. The tumours may be single, but when myxomatous they are frequently multiple.

TREATMENT.—The treatment of a tumour of this kind should be early removal. If it grows outside the nerve, it can generally be dissected off without interfering with the continuity of the nerve trunk. When, however, it grows in the substance of it, it may be necessary to excise a portion of the nerve containing the tumour, and then to perform immediate nerve suture (see p. 117).

MALIGNANT TUMOURS.

Malignant tumours in connection with a nerve are not uncommon, but they usually involve it secondarily, either by pressing upon it and stretching it as they grow, or by invading and destroying it, as is generally the case with carcinomatous tumours.

TREATMENT.—Tumours that can be removed should be excised early and freely along with the portion of the nerve implicated ; this should be followed, if possible, by immediate nerve-suture (see p. 117). When the tumour cannot be removed, the treatment can only be directed towards the symptoms, and surgical interference is only necessary when a sensory nerve is involved and unbearable pain is caused. Should this be the case, a portion of the nerve should be excised well above the tumour so as to prevent the transmission of impulses upwards. In a mixed nerve this operation entails motor paralysis of the parts supplied by the nerve, but this is of no moment, since the case must eventually end fatally ; the important point is to secure a moderate amount of comfort for the patient by the relief of pain. When the tumour is situated in regions where it is difficult to expose the nerve above the seat of pressure, as, for example, in pelvic tumours, division of the posterior nerve roots (see p. 130) may be carried out. The pain is thereby abolished and the patient much relieved for a time at any rate. Unfortunately, recurrence of the pain after a time is the rule, but in cases of malignant tumour the fatal result may ensue before there is time for this.

OPERATIONS FOR EXPOSING THE MAIN NERVE TRUNKS IN THE UPPER EXTREMITY.

The operations on the nerves of the head and neck are fully referred to in connection with the affections of those regions (see Vol. III.). In all cases where it is desired to expose a nerve, it is best, if possible, to

make a flap, and turn it upwards, downwards, or to one side, so that the scar shall not lie over the line of the nerve itself; thus there will be no risk of entanglement of the nerve in the scar tissue. This is, of course, not always possible where there is already a cicatrix present.

EXPOSURE OF THE MEDIAN NERVE.

It may be necessary to expose this nerve, for the purpose of either stretching it or suturing it after division. In the upper arm it is readily accessible; it lies on the outer side of the brachial artery in the upper third of the arm, crosses in front of it to its inner side about the centre and remains on its inner side in the lower third. It is rarely necessary to expose the nerve in the upper part of forearm, as it lies between the superficial and deep flexor muscles, and thus generally escapes injury. The usual situation, in which this nerve has to be exposed, is the lower third of the forearm or the front of the wrist.

In the Arm.—The nerve is exposed by an incision similar to that required for ligature of the brachial artery (see p. 218), and the steps of the operation are precisely similar.

In the Upper Third of the Forearm.—Here the nerve lies on the inner side of the radial artery, and dips between the two heads of the pronator radii teres. An incision similar to that for ligature of the radial artery in the upper third is made (see p. 220), and the pronator radii teres is exposed where it crosses the nerve. If a few fibres of the muscle internal to the artery be incised, or if the muscle be pulled forcibly inwards, the nerve is easily reached.

On the Front of the Wrist.—The nerve is exposed by making an incision an inch and a half in length, parallel to the tendon of the flexor carpi radialis and somewhat to its inner side. The deep fascia is divided and the tendons are pulled aside, when the median nerve will come into view between the tendons of the flexor sublimis and the flexor profundus digitorum.

EXPOSURE OF THE ULNAR NERVE.

In the upper third of the arm the nerve passes between the axillary artery and the vein, after which it leaves the vessel and pierces the internal inter-muscular septum to reach the interval between the internal condyle of the humerus and the olecranon process of the ulna; in this part of its course it is accompanied by the inferior profunda artery. Subsequently it passes between the two heads of the flexor carpi ulnaris, and, running down beneath that muscle and upon the flexor profundus digitorum, it reaches the wrist. At the junction of the upper with the middle third of the forearm, it approaches the inner side of the ulnar artery and runs down along it to the wrist. At the front of the wrist it lies close to the radial border of the pisiform bone, where it divides into two terminal branches.

In the Arm.—The best place to expose the nerve is about the centre of the arm, where it is about to pass through the internal inter-muscular septum. This is done by an incision about two inches long, situated about half an inch internal to that employed for ligature of the brachial artery (see p. 218). The internal inter-muscular septum is exposed and divided, and the triceps is pulled well backwards whilst the brachial artery and the septum are pulled forward; the nerve will be found upon the inner side of the triceps accompanied by the inferior profunda artery.

At the Elbow.—The nerve lies immediately behind the internal condyle in the interval between it and the olecranon, and can be felt by the finger, and exposed by a somewhat curved incision over the olecranon turning a flap inwards. This operation is not often required, but it may have to be done for a neuroma upon the nerve or for some inflammatory change about the internal condyle, giving rise to neuritis or to dislocation of the nerve forwards over the condyle. In the latter case, the nerve should be replaced in position after it has been exposed, and the fascia stitched over it so as to prevent the dislocation recurring.

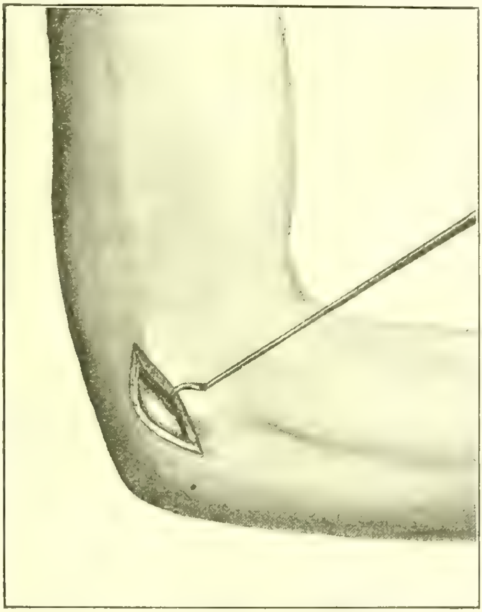


Fig. 50.—Exposure of the Ulnar Nerve behind the Internal Condyle.

Should the nerve require stretching, it is best exposed just above the condyle; it can be felt immediately behind the condyle and traced upwards until it passes towards the front of the arm. Here it may be cut down upon behind the internal inter-muscular septum.

On the Front of the Wrist.—Here the nerve is superficial and can be exposed by a small incision parallel to the tendon of the flexor carpi ulnaris, and on its ulnar side. After the skin and fascia have been divided, the nerve is seen with the ulnar artery lying on its outer side.

EXPOSURE OF THE MUSCULO-SPIRAL NERVE.

This is the largest branch of the brachial plexus, and is at first situated behind the third part of the axillary artery. Lower down in the arm

it is behind the upper part of the brachial artery, but it soon leaves the latter to run in the groove between the inner and outer heads of the triceps along with the superior profunda artery; in this groove it runs round the humerus and pierces the external intermuscular septum, passing downwards between the supinator longus and the brachialis anticus muscles. Just above the bend of the elbow it divides into the radial and the posterior interosseous nerves.

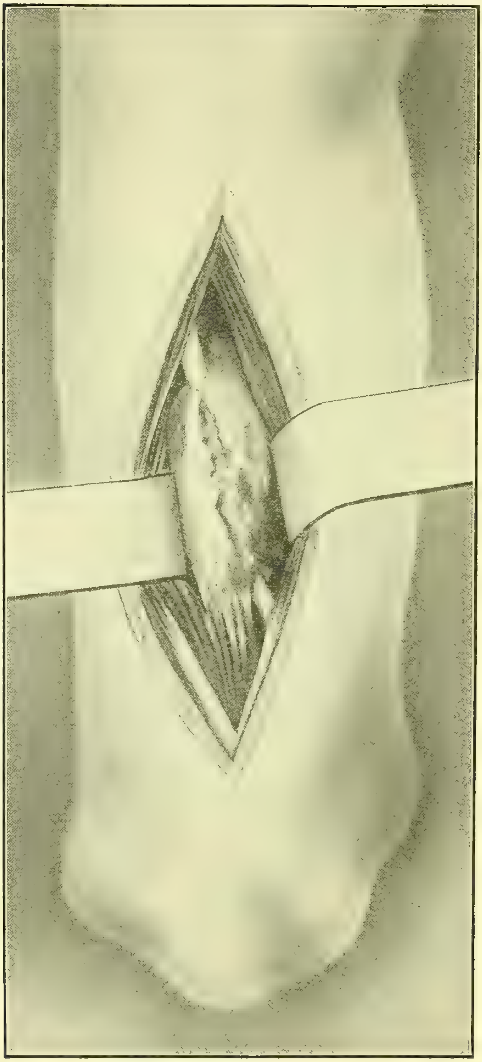


Fig. 51.—Exposure of the Musculo-spiral Nerve for Involvement in Callus.

The nerve may require exposure either on account of rupture, or of pressure upon it by callus after a fracture, or of neuritis from injury, and it is generally exposed about the middle of the upper arm, at which point it lies behind the humerus in the musculo-spiral groove close to the bone.

In the Middle of the Arm. — The best guide to the nerve in this situation is that given by Kocher, namely a line drawn along the posterior surface of the upper arm from a point a finger's breadth behind the posterior border of the deltoid, close to the long head of the triceps, down to the tip of the olecranon. The incision begins immediately below the axillary fold, and the interval between the long and outer heads of the triceps is identified and the two are separated down to the bone. The nerve will then be found close to the humerus, between the inner and outer

heads of the triceps; in front of it is the superior profunda artery which accompanies it.

In the Lower Third of the Arm.—Here the nerve lies in front of the humerus, between the supinator longus externally and the brachialis anticus internally. The elbow is flexed to an angle of 135°, the forearm is fully pronated, an incision is made over the intermuscular septum and the muscles are displaced outwards and inwards, when the nerve will be seen lying on the bone just before it divides into the two terminal branches—the radial and the posterior interosseous.

OPERATIONS FOR EXPOSING THE MAIN NERVE TRUNKS IN THE LOWER EXTREMITY.

The only nerves that are likely to require exposure in the lower limb are the great sciatic or its branches.

EXPOSURE OF THE GREAT SCIATIC NERVE.

This nerve runs vertically down the back of the thigh to below its centre, where it divides into the internal and external popliteal trunks. It lies first beneath the gluteus maximus and the biceps muscles, and it is generally exposed below the lower edge of the former. Its course is represented by a line drawn from the centre of the interval between the tuber ischii and the great trochanter to the middle of the ham. The nerve is exposed by an incision five or six inches long, along this line and commencing above at the gluteal fold, the patient being turned almost completely over upon the face, and the thigh fully extended. When the fibres of the gluteus maximus muscle are exposed, they are hooked well up out of the way with large retractors, the deep fascia of the thigh is divided, and the nerve is found by following the outer edge of the hamstring muscles, beneath and to the outer side of which it lies (see Fig. 52); these muscles are therefore pulled strongly inwards. The nerve is freed from the surrounding parts by a suitable dissector, two fingers are hooked around it, and it is gradually pulled well up out of the wound. It should always be pulled sufficiently far out of the wound to allow four fingers to pass between it and the back of the thigh (see Fig. 53).

EXPOSURE OF THE INTERNAL POPLITEAL NERVE.

This nerve runs downwards in the centre of the popliteal space considerably behind the artery and the vein, *i.e.* between them and the skin, and may be exposed by a vertical incision over the centre of

the ham. After the skin and fascia have been divided, the finger is passed in amongst the fat between the two heads of the gastrocnemius muscle, and will feel the internal popliteal nerve, which lies to the outer side of the popliteal vein. It is a stout round cord that is easily recognisable.

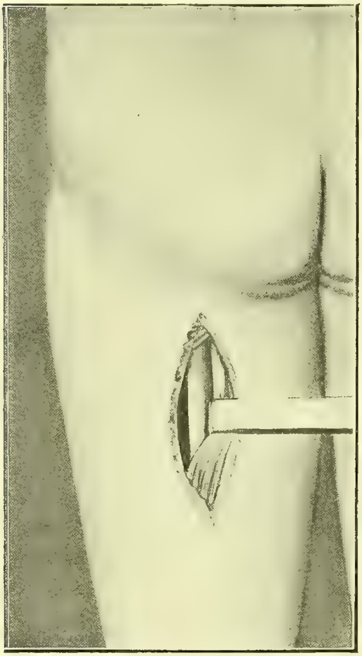


Fig. 52.—Exposure of the Great Sciatic Nerve. The hamstrings are being pulled inwards with a retractor in order to expose the nerve.

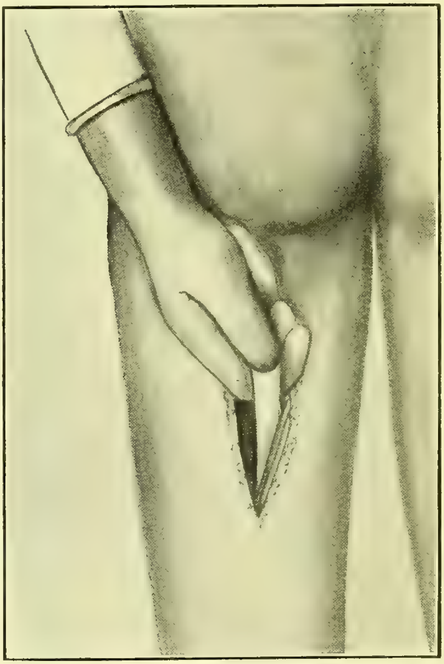


Fig. 53.—Stretching the Great Sciatic Nerve.

EXPOSURE OF THE EXTERNAL POPLITEAL NERVE.

This nerve may be exposed by a similar incision to the last, but it is more readily dealt with where it passes round the head of the fibula to reach the front of the leg. In order to expose it here, an incision is made along the posterior edge of the tendon of the biceps; the nerve will be exposed as it lies immediately below the fascia, along the outer edge of the gastrocnemius muscle. Below the head of the fibula the nerve pierces the peroneus longus and divides into its terminal branches.

EXPOSURE OF THE ANTERIOR CRURAL NERVE

Should this nerve require to be exposed, it is best reached where it passes into the thigh between the psoas and iliacus muscles. The nerve trunk has only a short course, as it soon breaks up into its terminal branches. The psoas muscle intervenes between it and the femoral artery. It should be exposed by a vertical incision two inches or more in length just external to the line of the artery; after the fascia lata has been divided, the hip joint is slightly flexed, and the nerve will be found on the outer side of the femoral artery.

CHAPTER XI.

AFFECTIONS OF VEINS.

WOUNDS.

WOUNDS of veins are of importance on account of both the immediate and the remote effects that they produce. The *immediate troubles* are (*a*) hæmorrhage and (*b*) entry of air into the vein. The *remote troubles* are thrombosis, embolism, pyæmia, and œdema of the part corresponding to the distribution of the vein. The immediate dangers are more common in connection with operation wounds; the remote ones in accidental injuries.

VARIETIES.—Wounds of veins are usually described as *punctured*, *incised*, and *contused*; as regards treatment it is better to speak of them as *operation* and *accidental* wounds. As a rule the bleeding from a wounded vein is slight and stops on light pressure, but in the large trunks, such as the internal jugular or the femoral, the hæmorrhage may be profuse and very serious, unless the bleeding point be compressed at once. The blood from a wounded vein is dark and escapes in a steady stream, but in a large vein, like the internal jugular at the root of the neck, the jet varies in height with inspiration and expiration. Wounds of veins heal readily, and complete occlusion of the lumen of the vessel by a thrombus does not necessarily occur; should it take place, the thrombus frequently becomes channelled at a later period by the formation of new vessels, and the circulation through the vein is eventually restored.

TREATMENT.—**Of Hæmorrhage.**—This has already been referred to in Vol. I. p. 106. In the smaller veins, temporary pressure alone, exerted either by means of a sponge or a pair of pressure forceps, is usually sufficient to arrest the hæmorrhage, and in a short time the wound in the vein becomes closed by adhesion, and no further bleeding occurs. In the large veins, some means of permanently closing the wound in the vessel should be adopted; unless this be done, pressure will have to be kept up for at least twenty-four hours, in order to prevent

the occurrence of hæmorrhage. When the vein has been divided completely or almost completely across, a ligature should be put around it above and below the seat of injury ; if only the distal end, from which the blood comes, be tied, it is frequently found that coughing or some sudden movement will force out blood from the proximal end. In the case of the larger veins in the neck, another reason for tying the proximal end of the vein is to prevent the risk of entrance of air into it. This would otherwise be very likely to occur, as there is considerable aspiration during each act of inspiration, and the veins are rigid where they pass through the openings in the deep cervical fascia and do not collapse properly. An additional reason for tying large veins, when they are divided, is that the pressure which may be exerted upon the vein between the wound and the heart by the bandage put on to retain the dressings in position may interfere with the return of the blood and lead to serious

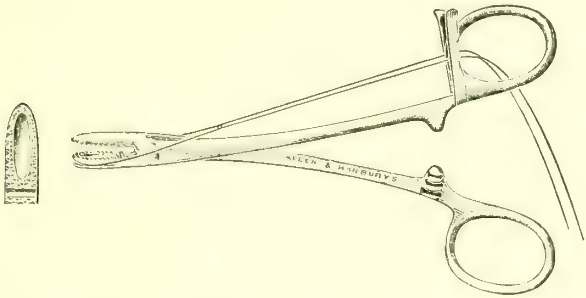


Fig. 54.—Schumacher's Artery Forceps. When the ligature is arranged as shown in the figure, the forceps are made to pick up the bleeding vessel. If the ligature be then tied, it must slip off the end of the forceps instead of tying them in.

hæmorrhage from the open distal end ; as soon as the bandage is removed this bleeding will cease. This point should be borne in mind in cases of secondary or reactionary hæmorrhage, because it is very seldom nowadays that bleeding of this kind is arterial. As a rule it will be found that when the dressing is removed the bleeding stops, and it is well, therefore, not to be in too great a hurry to open up a bleeding wound after the dressing has been taken off, unless it be quite certain that active arterial hæmorrhage persists in spite of its removal.

The forceps illustrated in Fig. 54 are often very useful in cases of deep-seated bleeding, as for instance in the mouth or the pelvis, and will often obviate the necessity of leaving instruments *in situ*. If the bleeding point can be commanded by them, there is no great difficulty in tying the ligature.

In some cases, when the vein is deeply seated and it is impossible to get a ligature around it, a pair of pressure forceps applied and left *in situ* for from 24 to 36 hours will arrest the bleeding satisfactorily without

causing any material disturbance in the healing of the wound. The latter should be stitched up, except immediately around the forceps, and at this spot a stitch is passed through the edges of the wound, but is left untied. The whole wound, including the handles of the forceps, is then enclosed in an antiseptic dressing, and at the end of from 24 to 36 hours, according to the size of the vein, the dressing is removed and the forceps taken off. The removal of the forceps must be effected most carefully; otherwise the vein may be torn open again. The catch of the forceps should be undone without any lateral movement, the blades then gently separated and withdrawn from the wound. The stitch previously passed and left loose should then be tied, and there will not be any further trouble.

When a large vein has only been punctured, or when a branch has been torn off at its junction with the main vessel, it is often a question as to what is the best thing to do. In the case of one of the large veins of the neck, such as the internal jugular, the simplest plan is to tie the vein above and below the puncture and divide the vessel between the ligatures; this causes no embarrassment to the circulation. When, however, the vein is one—such as the femoral, the axillary high up, or the renal vein—which it is not desirable to occlude owing to the great interference with the circulation which would result, some other procedure must be adopted. The favourite method is to pinch up the opening in the vein with a pair of forceps, and then to apply a ligature to the pinched-up part—in other words, a lateral ligature is put on. This may act very well if the operation be completed and the ligature be applied immediately before the closure of the wound; but if it be applied early in the operation it is very apt to slip or be pulled off during the subsequent manipulations, when, of course, the bleeding will recur and the opening in the vein will probably be larger than before. In the case of the largest veins it is a very good plan to sew up the opening in the vein with a fine round intestinal needle threaded with the finest catgut. The circulation through the vein must be arrested by pressure above and below the point of puncture while the rent in its wall is being closed. The puncture made by the needle is closed as the stitch is tightened, and this form of vein suture is not followed by thrombosis in the large veins and the circulation is not obstructed. This method is especially useful in cases of injury to the renal vein during operations on the kidney.

Hæmorrhage from veins in bones, as a rule, stops on pressure, but if it be persistent, the use of Horsley's aseptic wax,[1] will readily arrest it. A small piece of the wax is pinched off and kneaded in the hand until it is sufficiently soft; it is then firmly pressed into the hole from which the bleeding is taking place, and the wound is closed.

[1] Beeswax 7 parts, almond oil 1 part, and salicylic acid 1 part. It should be kept in a vessel of 1 in 20 carbolic acid solution.

When there is continuous oozing from a vein as it passes through dense fibrous tissue or lies in the periosteum where it cannot be picked up and tied, the best plan is to pass a curved needle threaded with a double thread of catgut under the bleeding point, and then to tie the ligatures, one above and one below the bleeding point, thus including both the vein and a portion of the surrounding fibrous tissue. As a rule, however, in venous bleeding there is not much trouble, and, with the exception of the axillary, the femoral or the renal veins, there need be no hesitation in tying and dividing them. Even in the case of the extremities, the swelling of the limb resulting from ligature of the main vein is often much less than one would expect.

Of Entry of Air.—This has been already referred to in Vol. I.; it is comparatively rare nowadays, but is most likely to occur in connection with the veins about the root of the neck, and hence in operating in that region every care must be taken to apply pressure immediately at or below any wound or puncture that may be inflicted upon any of the larger veins; while the pressure on the proximal side is kept up, the bleeding point should be clamped as quickly as possible. This dangerous complication can be further guarded against, by making a sufficiently large incision, so that the mass has not to be pulled up forcibly to get access to it (a proceeding which puts the veins on the stretch, and so renders any opening into them unduly patent), and also by taking care to clamp veins, especially on the proximal side, before they are divided. When air is sucked in—an occurrence usually indicated by a characteristic hissing sound—pressure should be at once applied to the proximal end of the vein, and the wound flooded with lotion so as to prevent more air entering. The treatment in cases where air has entered will be found in Vol. I. p. 123.

Among the remote complications of wounds of veins are phlebitis, thrombosis, and possibly embolism. If the thrombus be septic, it may break down, and portions may become detached and lead to abscesses in various parts of the body (see Pyæmia, Vol. I. Chap. IX.). Secondary hæmorrhage may also occur from a wound in a vein, but this is very rare nowadays, and generally only takes place in septic wounds in which the clot breaks down and the blood escapes from the end of the vein that is thus allowed to reopen.

INFLAMMATORY AFFECTIONS.

Inflammation of a vein or phlebitis is a very common affection, both as a primary disease and as a secondary complication.

PHLEBITIS AND THROMBOSIS.

By phlebitis is meant inflammation of a vein, and by thrombosis the formation of a coagulum, either white or red, or both, within the lumen

of a blood-vessel, generally a vein; thrombosis is a constant result of phlebitis. Inflammation may affect the lining membrane of the vein, when it is termed *endo-phlebitis*; or all the coats of the vein, when it is known as *phlebitis proper*; or the sheath of the vein and the tissues in which it lies, in which case it is called *peri-phlebitis*. The term phlebitis is, however, usually employed in the widest sense, and includes both endo- and peri-phlebitis.

CAUSES.—The condition may follow an injury which causes bruising of the wall of the vein and the formation of a thrombus in its interior; it may originate in connection with a septic wound; it may be associated with gout or rheumatism, or with poisons, such as alcohol or lead, circulating in the blood; or it may follow debilitating diseases such as typhoid fever, when it is probably of an infective character. It most frequently attacks veins which are already unhealthy, notably those that are varicose.

PATHOLOGICAL CHANGES.—The changes which occur in the vein are thickening of its wall, proliferation of its endothelial lining, swelling of the internal coat, and early formation of white clot, with ultimate blocking of the lumen of the vessel. The clot thus formed may extend upwards to the nearest branch; or, if a branch only be affected, the clot may reach the main vein itself, and may there project into its lumen. As a result of any sudden movement this projecting portion may become detached and carried on by the blood-stream, and give rise to an embolus; when the piece so detached is large enough to block the pulmonary artery, immediate death may result. The later history of the primary thrombus depends upon whether or not sepsis is present; in aseptic cases the clot becomes firmly adherent to the internal coat of the vein, and subsequently becomes partly absorbed and partly converted into new tissue. In the process of organisation, new venous spaces are often formed, and extend through the clot from one end to the other; the result is that the lumen of the vein may either be restored from this channelling of the new tissue, or the vein may be converted into a fibrous cord. Not infrequently earthy salts are deposited in the thrombus in long-standing cases, so that hard adherent calcareous masses are formed in the interior of the vein usually in the neighbourhood of the valves; these are often spoken of as *phleboliths*. When the clot is septic, pyæmia is apt to occur (see Vol. I. Chap. IX.).

SYMPTOMS.—The disease may run an acute, sub-acute, or chronic course. Acute phlebitis is accompanied by high temperature, diffuse redness of the skin over the vein, and œdema of the tissues in its vicinity; later on, when the thrombus breaks down, septic emboli or a localised abscess may form and pyæmia may develop. Between the acute and the chronic forms there are all sorts of gradations. In a typical case it is usual to find pain and tenderness and a hard cord in the course of the vein, with redness or dusky discoloration of the skin over it; the patient

is otherwise well and there may be little or no pyrexia. These cases demand care in treatment, because the patient is apt to under-rate the dangers, and there is often considerable difficulty in persuading him to lie up. The great danger in these sub-acute and chronic cases is the detachment of a portion of the clot, and immediate death from pulmonary embolism. Another danger is that movement may lead to extension of the thrombus, and, as a result, to serious interference with the venous return and possibly pulmonary embolism later.

Œdema is a frequent complication of phlebitis and thrombosis in the larger veins. How far it is due merely to the mechanical interference with the flow of the blood, and how far it is due to an altered and leaky condition of the capillaries, or to increased lymph formation or diminished lymph removal, are points which are still under discussion.

TREATMENT.—In the treatment of phlebitis and thrombosis it is important to determine, in the first instance, whether the case is septic or not. In the first case the chief danger is pyæmia; in the second, pulmonary embolism or extension of the inflammation to the main veins followed by severe œdema of the limb below.

Of Acute Septic Phlebitis.—The treatment of acute septic phlebitis has already been referred to in speaking of the treatment of pyæmia (see Vol. I. Chap. IX.).

Of Sub-acute and Chronic Phlebitis.—The first essential is to avoid the risk of the clot becoming detached and being carried into the general circulation. The patient should be *rigidly confined to bed*, and the affected part, if a limb, put on a suitable splint and somewhat elevated; the dangers of the affection should be explained and the patient ordered to keep quiet and avoid any muscular exertion which would tell on the inflamed vein. *Warm fomentations* used soon after the commencement of the disease are, as a rule, effectual both in relieving the pain and arresting the inflammation. When the pain is severe, the administration of *opium* may be called for; *digitalis* is also useful in the acute stage when there are no symptoms to contra-indicate it. The internal administration of citric acid or potassium citrate may be beneficial in preventing a further extension of the clot in the vein. A drachm or more of the acid may be dissolved in a pint of water, and the solution drunk *ad libitum*, or fifteen to twenty grains of the salt may be taken in an ounce of water every four hours. After the acute pain has subsided, *glycerinum belladonnæ* should be smeared thickly over the part, and a layer of cotton wool applied outside. The application should be merely spread over the surface of the skin without employing friction, otherwise there is a risk of disturbing the clot.

The limb should be kept at rest for at least three weeks. It takes about that time for a clot to become organised and adherent to the wall of the vessel in which it lies, and before then there is a risk that movement may lead to its detachment. In the clinical history of phlebitis, especially

when associated with gout or varicose veins, it is not infrequently found that after the lapse of a week or ten days, when the patient is apparently getting better, there is a fresh extension of the disease; therefore the patient's stay in bed must be reckoned from the appearance of the last extension of this kind and not merely from the first onset of the disease. Apart from the risk of the clot becoming detached, there is often immediate extension of the phlebitis, if the patient be allowed to get up too soon, and thus the effect of attempting to hasten matters is to cause considerable delay.

Phlebitis occurring in varicose veins may often be cut short by tying the vein well above the thrombosed area and then excising the thrombosed portion. This is the best treatment to adopt under the circumstances. Otherwise, it is often necessary to keep a patient suffering from inflamed varicose veins in bed for six weeks or more.

Gouty Phlebitis.—When there is gout, appropriate constitutional treatment must be adopted. A good local application is a lotion recommended by Dr. Burney Yeo, containing half an ounce of bicarbonate of soda crystals and two drachms of laudanum in ten ounces of water. This should be mixed with an equal quantity of hot water, and lint or soft linen wetted with it should be applied to the affected part, and some of the hot lotion poured over the dressing, which should then be covered with oiled silk overlapping it in all directions, and enveloped in cotton wool.

If the phlebitis be associated with an acute attack of gout, it is a good plan to administer colchicum combined with sulphate of magnesia. Dr. Burney Yeo gives the following useful formula:—

℞	Magnesii sulphatis	℥jss.
	Magnesiæ levis	ʒij.
	Potassii citratis	℥ss.
	Tinct. sem. colchici	ʒij.
	Aq. carui	ad ℥viij.

M. ft. mist. Two tablespoonfuls, with two of hot water, every three hours until the bowels have been freely relieved.

The sulphate of magnesia may be omitted after the bowels have been well relieved, and when the pain has subsided to a great extent, the mixture may be taken thrice daily, but it is well to give a dose of the original mixture each morning to ensure the proper evacuation of the bowels. The same authority gives the following formula for use when there is reason to avoid colchicum and when no aperient action is called for:—

℞	Sodii salicylatis	ʒij.
	Lithii salicylatis	gr. xl.
	Potassii citratis	℥ss.
	Tinct. zingib.	♏xx.
	Aq. cinnam.	ad ℥viij.

M. ft. mist. Two tablespoonfuls every two or three hours until the pain is relieved; then every five or six hours.

In chronic gout, the following formula is advised by Whitla :—

℞	Potassii iodidi	ʒij.
	Potassii bicarbonatis . . .	ʒvj.
	Vini colchici	ʒij.
	Aq. camphoræ	ad ℥xij.

M. ft. mist. A tablespoonful three times a day in a wine-glassful of water after meals.

The *diet* of these patients requires careful attention. Fat, starch, and sugar should be reduced to a minimum, and all meals should be light, simple, and easily digestible. For fuller details upon this complex subject, and also for information regarding the question of alcoholic liquors, the reader may with advantage consult the section on Gout in Dr. Burney Yeo's 'Manual of Medical Treatment.'[1]

Rheumatic Phlebitis.—Should the phlebitis occur as a complication or sequela of acute rheumatism, or in a person of a pronounced rheumatic tendency, the administration of salicylate of soda and iodide of potassium combined will be useful :—

℞	Potassii iodidi	ʒij.
	Sodii salicylatis	ʒj.
	Syrupi simp.	℥j.
	Aq. menth. pip.	ad ℥vj.

M. ft. mist. A tablespoonful thrice daily.

In the very chronic forms the following prescription is useful :—

℞	Sodii iodidi	ʒij.	
	Sodii bicarbonatis	℥ss.	
	Potassii bicarbonatis . . .	℥j.	
	Liq. arsenicalis	ʒjss.	
	Dec. sarsæ comp.	ad Oj.	(Whitla).

M. ft. mist. A small tablespoonful in a claret-glassful of effervescing potash water three times a day after meals.

Post-typhoid Phlebitis, etc.—In cases occurring after typhoid fever or debilitating illnesses, the administration of tonics, especially iron and arsenic, are advisable ; after the acute inflammation has subsided, change of air is beneficial. When the affection is sub-acute, as, for instance, in gonorrhœal rheumatism, of which phlebitis is a not uncommon complication, salicylate of soda, quinine, and iron are often of value. The patient, who is generally feeble, requires judicious feeding, and the state of the bowels should be attended to, saline purges being given as often as may be necessary, especially at the commencement of the illness. The general condition must be carefully watched ; should rigors occur, the septic character of the phlebitis becomes apparent, and appropriate treatment should be adopted (*vide supra*).

[1] Cassell & Company, London.

Treatment of the Resulting Œdema.—As a sequel to phlebitis of the main vein of a limb, there will be œdema of the parts below the block, which is often severe and slow to subside. The extent and duration of the œdema depend mainly upon whether or not vessels able to carry on the circulation open into the main vein above the seat of the disease and also, in some degree, upon the general condition of the patient, the nutrition of the tissues, the presence of anæmia, etc. Hence the treatment does not by any means necessarily come to an end when the phlebitis is cured.

The œdema must be treated by *pressure* and *massage.* Massage should not be begun for at least a couple of months after an attack, or carried out too vigorously, as otherwise fresh phlebitis may be set up. Even then, however, it should be very gentle in the immediate neighbourhood of the vein. At first it should be done every morning, for about twenty minutes, the frequency and length of the sittings being gradually increased; in the intervals, the limb should be firmly bandaged from below upwards, and kept elevated so as to promote the circulation. When the patient is allowed to walk, an *elastic bandage* should be applied from the foot to above the seat of the œdema, and this should be put on before he leaves his bed and after the employment of the massage. This will be referred to again in connection with varicose veins.

The patient's *general health* must also be attended to carefully. Plenty of nourishing food must be given, whilst amongst *drugs* iron and arsenic are the most useful.

VARICOSE VEINS.

By varix or varicose veins is meant a condition in which the venous trunks are both dilated and elongated. The lower extremity is the most usual seat of the disease, but the affection is also common in the hæmorrhoidal plexus—where it is known as piles—and in the pampiniform plexus—where it is termed varicocele. When varices occur elsewhere, particularly in the upper arm, they are usually due to some congenital malformation, though they may be due to pressure on the veins, aneurysmal varix, etc. We shall only deal here with varicose veins in the leg; varix elsewhere is treated of in connection with the regions in which it occurs.

CAUSES.—Varicose veins in the leg may be met with at almost any period of life, but they most frequently commence between the ages of twenty and thirty. Varix of the large trunks is much more common in men than in women—a fact accounted for by the more laborious occupations of the male sex; heredity seems to play an important part in the occurrence of the condition; anything which interferes with the circulation, such as pregnancy, may also lead to its production. Occupations involving long-continued standing, especially if associated with considerable exertion, are liable to lead to varicosity, and hence the affection

is very frequent among shopmen, barmaids, porters, washerwomen, etc. Habitual constipation and the use of tight bands, such as garters around the limb, are also common accessory causes. Gout is said to predispose to this condition.

PATHOLOGICAL CHANGES.—Obstruction to the circulation though it usually predisposes to, or aggravates existing varix, is not necessarily of itself the direct cause of the trouble. Before the varicosity develops, the walls of the veins become the seat of a chronic inflammatory condition. The first changes which occur are swelling and thickening of the walls, which lose their elasticity and become too weak to resist the pressure of the blood from above; the result is distension of the wall and incompetence of the valves of the vein. The veins also elongate, and stand out after a time as dilated and tortuous tubes. The distension is usually irregular, being greater about the valves; the most dilated portions may distend and thin the skin over them, and, indeed, sometimes burst through it.

The chief agent in bringing about the dilation of the veins is the pressure from above due to the weight of the column of blood, which is unsupported by the incompetent valves; the venous pressure from below is trivial. The subcutaneous tissue affords no real support to the superficial veins, and there is nothing to help them to sustain the weight of the column of blood when the valves have become incompetent. In the deep veins, on the other hand, the contraction of the muscles drives on the blood, and also gives support to the walls of the veins lying beneath and among them; the reason that prolonged standing leads to varicosity is that the muscles are not then in action, and do not give this support when the patient is erect and the full weight of the blood-column tells on the wall of the veins. The influence of this downward pressure has an important bearing on treatment.

VARIETIES.—With regard to treatment, varicose veins may be divided into two distinct classes. In the first only the larger subcutaneous venous trunks are dilated, and in the second there is a varicose condition of the small veins in the skin itself, with or without dilatation of the main veins. In the latter case the skin of the affected part is mottled with numerous small dilated veinules and this latter condition is the one most often associated with ulceration, and most difficult to relieve.

COMPLICATIONS.—When the condition is marked, there is often *œdema* of the extremities, resulting from the embarrassment of the circulation produced by standing and the absence of sufficient muscular movement to force on the blood in the limb, and also from the imperfect nutrition of the tissues. In the earlier stages the œdema is only noticeable towards the end of a long day's standing, just above the instep and ankle, and disappears when the patient lies down.

Varicose veins are prone to inflammation, and *phlebitis* is, therefore

a common occurrence. Varices in the legs are also fertile sources of *eczema* and *ulceration* (see Vol. I. Chap. III.). They also cause *pain* and aching in the limb, and in the early period this is chiefly noticeable when the patient gets up in the morning, when it is often accompanied by *cramp*; later on, it is chiefly marked in the evening if the patient has been standing much during the day.

TREATMENT.—The treatment of varicose veins in the leg may be palliative or operative. In no case can a cure be correctly spoken of, although marked improvement may be effected by operative means in suitable cases. Even when it is possible to eradicate a small localised mass of veins entirely by operation, it is not strictly accurate to speak of this as a cure, as is often done. The tendency to varix remains, and other veins may become affected. The primary object of the treatment, whether palliative or operative, is to support the column of blood and relieve the weakened venous walls of the downward pressure.

An *operation* is advisable *as a radical measure* when the varicosity is not extensive, and the enlargement is limited to one vein or set of veins. The operation is also necessary in cases of young men entering the public services or going abroad to hot climates, where they are likely to have much standing or exertion. *As a palliative means* it is to be recommended in cases of extensive varix, with the view of rendering the patient more comfortable, of diminishing or arresting the spread of the condition, and of enabling him to wear an elastic stocking with comfort, even when large areas are affected. Operation is indicated when the enlargement affects the veins above the knee, in order to cut off the blood-column and to obviate the necessity of wearing a bandage above the knee—a most irksome thing. It is also advisable when there have been frequent attacks of phlebitis, or when the veins are the cause of much pain or aching, even without phlebitis. When there is ulceration of the limb, ligature and removal of the veins, after the ulcer has healed, is often of value, as it tends to prevent recurrence (see Vol. I. Chap. III.). Excision of the inflamed veins during the acute stage is also indicated in phlebitis associated with varicose veins.

Non-operative measures are indicated when the patient objects to an operation, when the state of his health contra-indicates operation, when the varicosity is slight, stationary, or easily controlled by supporting bandages, when the condition is extremely extensive and when the cutaneous veins are the chief seat of the enlargement.

Operative Treatment.—We shall discuss, first, the operative treatment of varicose veins, in which the object is to shut off the downward blood pressure and obliterate the main vessels affected. When the disease extends into the thigh and affects the internal saphenous vein up to the groin, radical measures are always advisable if the patient's health permits, because the valves are incompetent, and cannot support the column of blood. In these cases the important point is to block the

internal saphena vein close to its junction with the femoral. At first sight this would seem likely to increase the varicosity by interfering with the return of the venous blood, but the blood pressure from below is so slight, and there are so many communications with the deeper veins, that the application of the ligature is not nearly so harmful as the weight of the column of blood after the valves have become incompetent.

Removal of a portion of the internal saphena high up (Trendelenburg's operation) is only necessary when the vein is dilated in the thigh and the valves are incompetent. Some surgeons, in Germany especially, are content with removal of the saphena at the groin, and leave the other enlarged veins untouched; but as the superficial and deep veins communicate behind and at the inner side of the knee, and in the upper part of the leg, the downward pressure upon the veins of the leg is not entirely cut off by the obliteration of the saphena alone. We make it a rule, therefore, not only to excise a portion of the saphena as high as possible, but also to remove any masses of enlarged veins about the knee or popliteal space, and any much dilated groups in the leg which threaten to burst through the skin; any dilatations at the points of junction of a number of veins should also be taken away. Hence, in an ordinary case there may be five or six other places in which veins should be excised, besides the internal saphena.

As a preliminary to operation in all cases the veins should be marked out before the patient is placed under the anæsthetic; an excellent way to do this is to paint a solution of nitrate of silver (60 grs. to the oz.) over the portions of the veins to be removed with a camel's hair brush the day before the operation, followed by a 5 per cent. solution of pyrogallic acid, applied as soon as the silver solution has dried, which will bring out the silver stain at once. In this way a sufficient staining of the skin is obtained, which will not be effaced by the most energetic disinfection. If an ordinary flesh pencil or aniline dye be used, the stain is sure to be rubbed off while the skin is being disinfected. On no account should a stronger solution of nitrate of silver be employed than the one recommended above, otherwise blistering or even sloughing of the skin may result. This definition of the veins to be excised saves much time and simplifies the operation.

Occasionally the nitrate of silver method is not available, and under these circumstances we have found a useful substitute for it is to mark out the enlarged veins, when the patient stands erect, with an aniline pencil or a thin line of tincture of iodine. To avoid the marking being obliterated during disinfection of the skin we scratch the latter along these markings with the point of a knife before proceeding to disinfect the skin. The bleeding scratch is of course readily recognised.

Excision of Veins.—The operation consists in removing a portion of the veins at the various points thus marked out. The larger the portions removed at any one point, and the more branches that can be

included in the area of the operation the better. Strict asepsis is imperative, for the slightest suppuration may lead to septic thrombosis or to a septic ulcer, which will be slow in healing on account of the varicose condition.

The limb should be shaved and thoroughly disinfected (see Vol. I. p. 100), raised, rotated outwards, and the knee flexed and steadied upon a suitable sandbag ; an incision two or three inches long is then made over the portion of the vein to be removed. The group of veins highest up the limb should be removed first ; for example, the first incision should be for removal of the internal saphena close to the groin, the veins about the knee and leg being excised after this has been done. When a long portion of a straight vein such as the internal saphena is to be removed, the incision should lie directly over the long axis of the vein. When only small portions of a vein are to be excised, the incision may be made either directly over the portions to be removed, or somewhat obliquely to the long axis of the vessel. The skin incision must be made cleanly with a sharp scalpel, and at right angles to the surface of the skin, and care must be taken not to go deeply enough to wound the vein. The difficulty of the operation is greatly increased if an accidental puncture

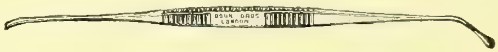


Fig. 55.—Fine Dissector.

of the vein should occur ; as long as this is avoided the operation, though somewhat tedious, is fairly easy.

After the skin and fat have been divided, the vein is seen to stand out, usually irregularly, as it is tied down by bands of fibrous tissue running across it from the deep surface of the skin. These bands must be divided, and then the skin is raised from the dilated vein by means of a few touches with the point of the knife. In doing this, the edges of the skin must not be bruised by holding them tightly ; forceps should only be used for just raising the edges of the skin, and as soon as sufficient has been liberated, the skin should be grasped between the finger and thumb. When the skin has been raised from the veins, the separation of the latter from the cellular tissue, in which they lie, is readily effected by means of a blunt-poitned dissector (see Fig. 55). Care must be taken not to include any branches of nerves in the ligature along with the vein, or great pain may result. When the vein and its branches have been isolated throughout the whole length of the incision, a pair of pressure forceps should be put on the upper end, another on the lower portion, and others on all the branches, the veins being pulled out of their bed, so that as much as possible is removed. The vein is then cut away between the various clamps, each separate branch tied with fine catgut and the forceps removed. A piece of gauze is thrown over the wound,

and then the next group of veins is dissected out ; by excising the remaining veins before sewing up the first wound, time is allowed for all bleeding to become arrested—an important element of success in attaining primary union in these cases.

When all the masses of veins have been removed thus, the various wounds are sutured with the finest silk. If the operation be done carefully, there will be little or no blood lost, but in all cases it is important to let the wound become quite dry before it is sewn up. Care must be taken to see that the thin skin does not curl inwards during the suturing ; the suture used should be the ordinary button-hole one described in Vol. I. p. 142 ; no drainage tube is necessary. The limb is put on a light splint for a few days to prevent bending of the knee, and the limb is elevated slightly. The dressing over the upper end of the saphena vein is apt to become detached by the movements of the patient, and, therefore, should be fixed on by collodion.

After-treatment.—The stitches may be removed at the end of ten days, and collodion dressings applied. The patient should not be allowed to get up until three weeks have elapsed since the operation, in case thrombosis should have occurred above the ligatures, when there will be a risk of detachment of clots if he begins to move about too soon.

When both limbs require to be operated upon, it may be advisable to operate upon one at a time, the second operation being done about a fortnight after the first, as it is exceedingly irksome to the patient to have the two limbs disabled at the same time. The operation is generally tedious, and it is not uncommon for it to last upwards of an hour upon each leg. When, however, the affection is only slight, and few veins have to be removed, or when it is severe in one limb and slight in the other, both may be operated upon at once. If the affection be very limited, no splint need be applied, the limb being enveloped in a thick mass of cotton wool, which will hinder the movements of the knee ; the limb may be kept steady, if necessary, by being placed between sandbags with a sheet or towel over it.

When the patient gets up it is well to apply a bandage from the foot upwards to support the veins before getting up out of bed, but this should be an ordinary cotton or flannel bandage, and not an elastic one. When the varicosity has not been very marked, and the affected veins have been almost completely extirpated, this bandage may be left off after three or four weeks and no further apparatus is necessary ; when, on the other hand, the varicosity is extensive and all the veins have not been dealt with, it is advisable to order a light elastic stocking or bandage (see p. 160) to be worn. After these operations exercises designed to improve the nutrition of the muscles may be practised, but the patient should be warned against prolonged standing, lifting heavy weights, and so forth ; active exercise, walking or bicycling in moderation, should not be prohibited, however. The bowels should be kept acting regularly.

Trendelenburg's operation is performed in the following manner: The thigh is flexed, abducted, and externally rotated at the hip joint, so that it occupies a position similar to that in which it is placed for ligaturing the femoral artery. The spine of the pubes is identified, and a curved transverse or an oblique incision (see Fig. 56), two inches long, is made across the line of the saphenous vein about two inches below the pubic spine. A flap of skin and subcutaneous tissue is raised towards Poupart's ligament so as to expose the vein, just before it passes through the saphenous opening. As soon as the vein has been exposed, the dissection is carried out close to it, so as to disturb the fat as little as possible, and thereby avoid leaving a cavity beneath the skin flap. The vein is isolated for a distance of two inches. A ligature is placed on its upper end, half an inch below its junction with the femoral vein, and a second ligature is placed at the lower end of the exposed portion. The intervening portion is removed.

Fig. 56.—The Incision for Trendelenburg's Operation.

The vein is more readily found by making a transverse instead of a longitudinal incision. Two or three tributaries may require to be tied, and the vein should be divided at least one-third of an inch below the upper ligature, so that if the patient strains or coughs, the ligature shall not be detached. Such an accident would be followed by severe hæmorrhage.

Various other operations have been described, but none, with the possible exception of Mayo's, are as efficient or as simple as that just described.

Mayo's Subcutaneous Enucleation.—The saphenous vein is exposed near to the saphenous opening, and divided between two ligatures. The distal end is clamped with a pair of pressure forceps and passed through the loop of a special dissector (Fig. 57). The dissector is pushed along the vein as far as possible towards the knee and then a short incision is made over the end of the dissector to expose it and the vein. The latter is pulled out of the wound, ligatured and divided, and the loose portion removed. A similar procedure is carried out on any other veins which require to be dealt with. If the passage of the dissector through the subcutaneous tissues be hindered by the vein being adherent, a special forceps is introduced along it with the blades closed. On reaching the

adherent portion of the vein, the blades are opened, and the adhesions are stretched or broken down, so that the dissector can be pushed along still further. A twisting movement will also facilitate removal of the portion it is desired to remove after it has been divided below.

This operation should be always performed from the proximal to the distal part of the limb, so as to avoid the risk of detaching thrombi into the blood-stream.

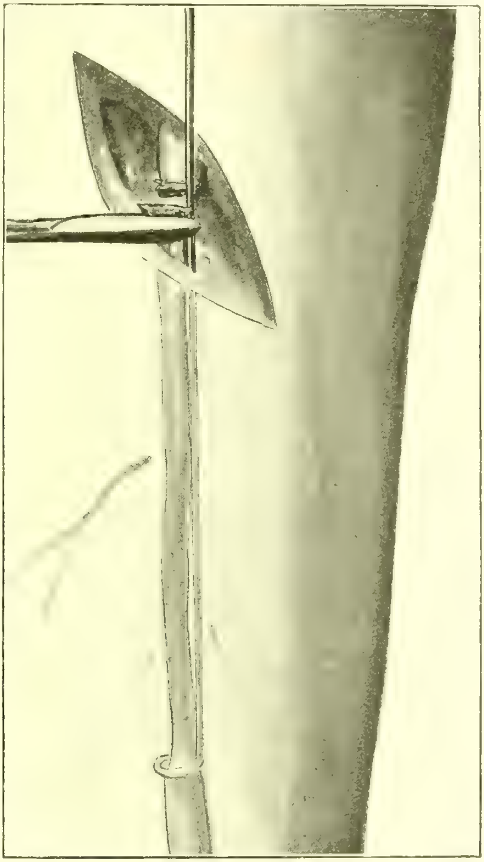


Fig. 57.—Mayo's Subcutaneous Enucleation of Varices. The sketch shows diagrammatically how the dissector is pushed down along the vein after it has been divided above.

Palliative Treatment.—Any *cause*, which predisposes to the varix, should be removed if possible in the first place. Garters should be interdicted, the stockings being upheld by suspenders. Constipation should be remedied by appropriate means, and when the trouble is due to pregnancy, the recumbent position should be assumed as much as possible. In fact, anything that is found to be causing pressure on the veins should be relieved or removed.

In the second place steps must be taken to *relieve the congestion of the extremity*, and facilitate the venous return. While the patient is at rest, the limb should be elevated so as to aid the return of blood, and diminish any œdema present. Except in very severe cases, it is unnecessary to confine the patient to bed or even to the couch, but the limb should be placed on a suitable rest at a higher level than the pelvis, whenever there is an opportunity of sitting down. If this can be done frequently during the day, it will do a good deal to prevent increase of the affection. The return of the blood may be facilitated still further by gentle *massage* of the limb from the foot to the groin. The rubbing should be applied very gently, otherwise it is apt to cause injury to the delicate walls of the veins, and may lead to phlebitis and thrombosis. All that is

necessary is to rub the limb in the upward direction with the open hand, which should be well oiled. *Active exercise* in moderation is also of value ; moderate walking, bicycling, horse-riding, and golf may be indulged in without fear of aggravating the disease, but the exercise should not be persisted in for too long at a time, and it should be varied as much as possible. The muscular contractions involved in these exercises help to force the blood onwards through the veins, while the exercise keeps the patient in better condition, makes him less flabby, and prevents him from putting on too much fat. The point that should be specially guarded against is continued standing, or sitting with the legs dependent.

The third, and perhaps the most important, part of the palliative treatment is *mechanical support* to the veins. This support usually takes the form of bandages or stockings containing elastic material, which aim at supporting the vein and exerting equable pressure from below upwards.

The India-rubber Bandage (*Martin's*).—The most useful form of compression is the application of a bandage, by means of which the pressure can be varied at will, and can be so regulated that it is uniform and is always exerted in the right direction. An elastic stocking, on the other hand, unless made with extreme accuracy, is apt to press injuriously on the limb somewhere, and the compression does not vary according to the needs of the case ; the stocking, as usually made, constricts the limb above, and so actually aggravates the mischief it is designed to alleviate. The best bandage is Martin's india-rubber bandage, perforated with holes to permit the escape of the perspiration. It is cheap and does not perish so soon as elastic webbing, while it can be kept much cleaner. It should be applied while the patient is in the recumbent position, and should reach from the instep, just behind the root of the toes, to just above the upper limit of the affected veins. Before the bandage is put on, the limb should be washed, dried, and powdered either with starch or with equal parts of oxide of zinc and starch. Many patients develop eczema or intolerable pruritus if the elastic bandage be applied directly to the skin. A white silk or cotton stocking should therefore be drawn smoothly over the limb first ; it is well to have this washed at home so as to avoid any risk of irritation from chemicals employed at the laundry. The bandage is wound lightly round the limb in the ordinary spiral form over the stocking. A little swelling of the limb is sure to occur when the patient assumes the upright position, and this renders the bandage sufficiently tight ; if it were put on tightly at first, the pressure would soon become intolerable. Indeed, even when put on loosely, many patients find it necessary to remove and readjust it towards the middle or end of the day, because it becomes too tight. The final turn of the bandage, either above or below the knee, must not be drawn tight, as otherwise it will act as a greater and constrict the limb. The pressure must be uniform ; if it

varies at all it must be greatest at the foot, gradually decreasing as the knee is reached.

The cheapness, the durability, and the readiness with which it can be adjusted to alterations in the size of the limb make this form of rubber bandage the most widely popular one that we have at our command It is especially suitable for hospital patients, and in private practice should always be employed where any great muscular exertion, such as walking, riding, shooting, or the like is being practised by the patient.

At bedtime the bandage should be left off, and it is always well to sponge it over so as to remove all traces of perspiration, and then to hang it up to dry. Used in this way it causes a minimum amount of irritation.

Elastic Bandages.—Some patients cannot tolerate Martin's bandage for any length of time, even over a stocking, and in that case an elastic webbing bandage will suit them better. This has the advantage that it is more porous and more comfortable to the limb, but it is less easy to apply owing to its greater rigidity, it quickly wears out, and will not stand much washing ; it requires frequent washing, because it readily becomes foul from the absorption of the sweat, and, therefore, it is a more expensive bandage than Martin's. Bandages of webbing known as crêpe Velpeau are very comfortable and useful in the milder cases.

Elastic Stockings.—Woven elastic stockings, made for each individual patient, are largely worn, and are satisfactory. They do not give such good support as Martin's bandages, however ; they seldom fit the limb accurately, and they are constantly made somewhat narrower above, so as to prevent them from slipping down, and thus they act practically as a garter. This is a very serious fault, and in ordering an elastic stocking stress must be laid on the point that the upper part shall not be constricted. The best form is that known as the *spiral silk elastic stocking*, which practically consists of a long strip of elastic webbing encircling the limb spirally, the adjacent edges of the bandage being united. Elastic stockings have the advantage over the rubber bandage in being porous, and they are, on the whole, more comfortable. They are, however, more costly, less durable, and more difficult to keep clean.

The elastic stocking should extend to the upper limit of the disease ; when the saphena vein is affected it must extend right up to the groin. Many patients, however, refuse to wear them as high as the groin, for they find that they constantly slip down and are extremely uncomfortable. It is with the view of meeting the wants of these patients that obliteration of the saphena vein alone (Trendelenburg's operation) may be done with great advantage in very bad cases of varicose veins of the leg, where there is no chance of curing the disease by operation, so as to avoid the necessity for a thigh-piece, and at the same time to relieve the pressure on the veins below.

CHAPTER XII.

AFFECTIONS OF ARTERIES.

WOUNDS.

Wounds of arteries are generally treated by ligature or some other form of occlusion of the lumen of the vessel, and this is dealt with in connection with the treatment of wounds (see Vol. I. p. 106). Recently, however, it has been found possible to unite the divided ends of large arteries by suture, instead of tying them as would be the ordinary procedure. The results are said to have been satisfactory in some cases ; that is to say, the lumen of the artery has remained patent, the blood has flowed on as before, and the wound in the vessel has healed, instead of a thrombus forming and obliteration of the artery resulting as one would naturally expect. It is very seldom that the opportunity of carrying out such a procedure will present itself. Apart from transverse division of arteries, punctured wounds of large arteries may be treated by arterial suture or *arteriorrhaphy*. This especially applies to the common carotid artery, ligature of which is very likely to be followed by hemiplegia and death.

The technique of the operation is briefly as follows.[1] As a preliminary

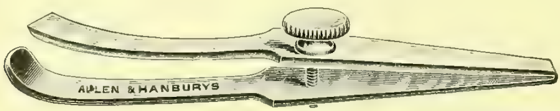


Fig. 58.—Crile's Clamp for Temporary Hæmostasis. The blades should be sheathed in rubber tubing.

measure the circulation through the vessel is commanded above and below the wound by a suitable clamp, such as Crile's (see Fig. 58), by traction

[1] For full details as to this subject the reader may be referred to *A System of Operative Surgery*, edited by F. F. Burghard, vol. I. p. 261, Oxford Medical Publications.

on a temporary ligature (see Vol. I. p. 106) or by digital pressure. It is generally agreed that coagulation, followed by complete obliteration of the lumen of the vessel, will inevitably follow if any foreign body or even any rough surface projects into the blood-stream. Hence in suturing, the object is to approximate the inner surfaces of the intima on each side of the wound, so that the wall of the artery is quilted up (see Fig. 59),

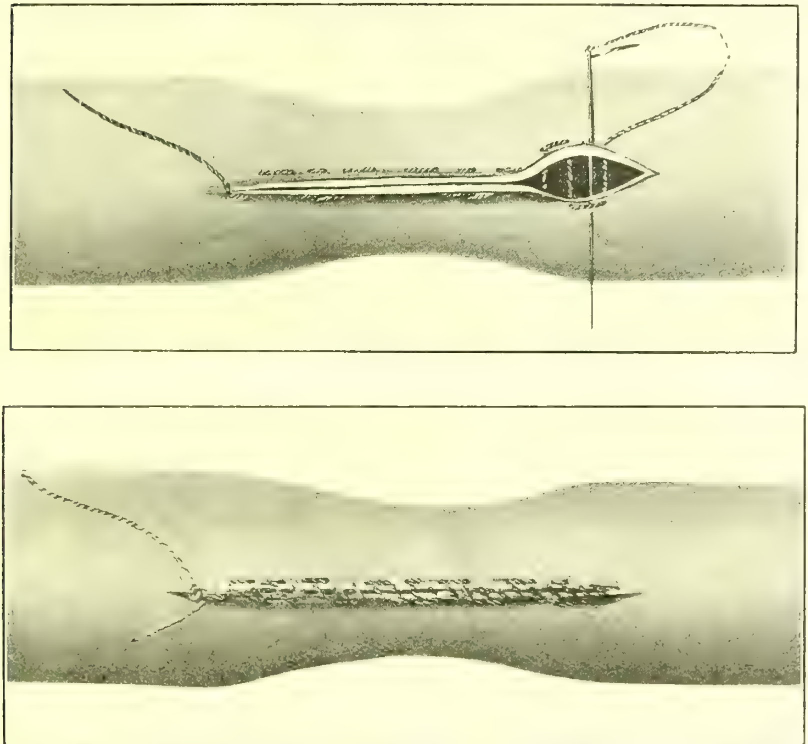


FIG. 59.—ARTERIORRHAPHY FOR PARTIAL DIVISION OF AN ARTERY. The upper figure shows how the deeper or quilting suture is put in and the method of securing it against gaping by carrying the needle back every third stitch. In the figure the needle is represented in the act of doing this.
In the lower figure the second or running suture has been put in over the first.

and the suture quilting it up is buried between the two surfaces out of contact with the blood-stream. The sutures are of the finest silk obtainable, threaded on the finest possible round needles ; each suture should be drawn through sterilised vaseline before use, so that the hole in the arterial wall may be caulked, as it were, and leakage through the stitch holes prevented. Figs. 59 and 60 show how the sutures are inserted both for an incomplete and a complete division of an artery.

This operation in either of its forms can only be called for very rarely. Moreover, it is not certain that it averts occlusion of the vessel in any case.

But, if thrombosis does occur, the process is more gradual than the sudden occlusion of the vessel by means of a ligature, which is the only alternative, and hence time may be gained for the collateral circulation to become sufficiently established to prevent the parts supplied by the artery from being completely deprived of blood.

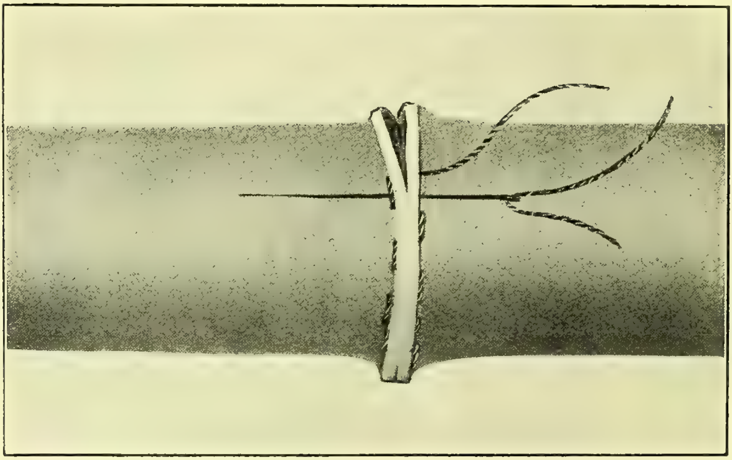


FIG. 60.—ARTERIORRHAPHY FOR COMPLETE DIVISION OF AN ARTERY. The first suture only is represented. It shows how the edges are quilted up by it. The needle is represented as making the binding suture by being carried back behind its last point of exit instead of in front of it as in the previous two.

As far as present experience goes it would appear that arteriorrhaphy should be attempted in preference to ligature in cases of wounds affecting the common carotid, the iliacs, the axillary, or any larger artery.

Injuries of arteries, either in the form of contusion of the coats or subcutaneous rupture, unaccompanied by a wound in the skin, will be referred to in connection with aneurysm, as will also punctured wounds of the skin involving an artery.

INFLAMMATORY AFFECTIONS.

Like other structures, arteries may be the seat of either acute or chronic inflammation.

ACUTE ARTERITIS.

Acute arteritis involves all the coats of the artery, and usually results either from the presence of a septic thrombus in the interior or from extension of inflammation from the surrounding tissues to the coats of the artery ; in the latter instance a peri-arteritis occurs first.

Treatment.—The ordinary sequela of acute arteritis is the occur-

rence of *multiple abscesses* and *pyæmia*, and acute aneurysm. Acute arteritis is usually part of an extensive septic process, and is not a disease strictly limited to the coat of the artery itself ; treatment therefore can seldom be brought to bear directly upon the inflammation of the arterial coat, and the chief attention must be directed to the general septic condition. The question of ligaturing the vessel above the seat of inflammation, in cases where acute arteritis affects the extremities, is one which must be carefully considered ; the object of the procedure is to prevent the displacement of the breaking-down clot and to clear out clots already present, on principles similar to those that guide us in the treatment of septic phlebitis. When the case is one of *peri-arteritis*, the treatment of the inflammation in the vicinity of the vessel is the chief point ; here there may be not only thrombosis and septic embolism, but softening of the vessel wall with rupture, and hæmorrhage into the tissues or through an open wound. Such an accident is, however, of extreme rarity. The general treatment must be that of pyæmia (see Vol. I. Chap. IX.).

CHRONIC ARTERITIS.

ENDARTERITIS OBLITERANS.—One of the commonest forms of chronic arteritis is endarteritis obliterans, in which the internal coat becomes thickened, and ultimately either obliterates the lumen of the vessel or leads to thrombosis. This condition may occur in various diseases, particularly syphilis—in which it affects the small vessels—alcoholism, diabetes, etc.

ATHEROMA.—This is a more chronic and limited form of endarteritis, which is of great importance in connection with aneurysm. In atheroma the inflammation occurs in the deeper part of the internal coat of the artery, and results in the formation there of a mass of young cells which tend to undergo organisation into fibrous tissue. This attempt, however, usually fails ; fatty degeneration takes place, and either the degenerated mass bursts into the interior of the artery (the condition spoken of as *atheromatous abscess*), or lime salts are deposited in it and form *calcareous plates* which render the artery rigid and which also project through the endothelial lining membrane ; coagulation subsequently takes place on the rough edges of these plates. This condition rarely remains limited to the internal coat, but spreads to the middle one, and there leads to softening and partial destruction of the muscular tissue. The result is either weakening and dilatation of the vessel wall, or calcification of the middle coat, the vessel becoming converted into a calcareous tube. Atheroma is usually diffuse, and affects a number of vessels, especially the larger ones such as the aorta. It occurs chiefly in old people, more often in men than in women, and it seems to bear some relation to syphilis, gout, and the other conditions predisposing to endarteritis.

Treatment.—There is practically no cure for these inflammatory conditions of arteries. The only thing left for the surgeon to do is to try to arrest the spread of the disease, and particularly to guard against the consequences that may ensue. Drugs, such as iodolysin have been employed but without any definite success.

The chronic forms of arteritis are often associated with the various constitutional conditions already mentioned; when the arteries are becoming thick and hard, and when other signs, such as cold extremities, or perverted sensations, which betoken the occurrence of atheroma, are present, any constitutional affection which might lead to chronic arteritis must be sought for and, if possible, remedied. The patient should also be warned against doing anything which might precipitate the onset of any of the ordinary sequelæ of the disease. One of the most common of these is gangrene, which may result either from thrombosis in the vessel, or from the gradual narrowing of its lumen without thrombosis; this has been already dealt with (see Vol. I. p. 72). The other common sequela of chronic arteritis is aneurysm (*vide infra*). Anything, therefore, which injures parts already imperfectly supplied with blood, or which throws an extra strain on the walls of the vessel, must be rigorously avoided.

ANEURYSM.

By the term aneurysm in its widest sense is understood a cavity containing blood communicating by an opening of variable size with the lumen of an artery. According to this definition, two conditions are met with which are spoken of respectively as true and false aneurysm. By a **true aneurysm** is meant one in which the sac was originally formed by dilatation of one or more of the coats of the artery; in other words, its formation is preceded by a weakened or diseased condition of the vessel wall. By a **false aneurysm,** on the other hand, is meant one in which the wall of the sac was never constituted by any part of the original vessel wall; in other words, there must be a solution of continuity of the wall of the artery in the first instance. A true aneurysm is thus of pathological, a false aneurysm of traumatic, origin.

FALSE ANEURYSM.

CAUSES.—A false or traumatic aneurysm may arise in one of two ways; in the first there is a wound in the wall of an artery (it must be simply a hole and not complete division of the vessel), and the blood passing out through the aperture clots in the surrounding tissues and leads to condensation of the structures around; the result is that a sac is formed which prevents the further escape of blood into the planes of cellular tissue. The wall of this sac is composed of dense cellular tissue and organised blood-clot.

In the second, the wound in the wall of the artery may heal and leave a cicatrix. Dilatation of this cicatrix then occurs, with secondary condensation of the tissues around, and thus again a sac is formed, the wall of which is never composed of any portion of the original coat of the vessel. This mode of formation of a false aneurysm, however, is rare.

A false aneurysm may also result from subcutaneous rupture of an artery, provided that the rupture be small. Usually, however, the rupture is of considerable size, and blood is poured out into the tissues rapidly and in large amount ; indeed, the bleeding may be so free that the patient dies directly from hæmorrhage into the cellular tissue, or, at a later date, from gangrene as the result of the pressure of the effused blood upon the collateral circulation. This condition has received the name of **diffuse aneurysmal hæmatoma.**

False aneurysm most frequently occurs when the wound in the artery is very small, and when the injured vessel is in the neighbourhood of structures that offer considerable resistance to the outflow of blood ; it generally follows small punctured wounds of an artery. This false aneurysm has all the ordinary clinical features of the true variety, with the important difference that the walls of the artery are healthy up to the aperture of communication with the aneurysm. Its further history is practically the same as that of true aneurysm. It gradually increases in size, fresh tissue becomes inflamed and condensed around it, bones and other structures become absorbed as the result of the pressure and inflammation it causes, until finally the aneurysm reaches the skin or some internal cavity, when its wall gives way and fatal hæmorrhage results.

Formerly false aneurysm was a common sequela of venesection, and it usually occurred in connection with the brachial artery at the bend of the elbow. The lancet was apt to go too deep in dividing the vein, and the artery was punctured ; the immediate rush of blood was arrested by the pressure of the pad, but when the wound had healed and the pad was left off, blood continued to escape through the incision in the artery, and led to the formation of a false aneurysm.

TREATMENT.—This will depend very largely upon the situation of the aneurysm. When it is in an extremity or an accessible part, the usual treatment is to control the circulation either by digital pressure or by a tourniquet—if there be room above the aneurysm—to cut down and expose the sac, lay it open freely, turn out the clots, search for the opening in the vessel, clear the artery above and below the sac, and tie it in both places. Any branch coming off between these ligatures must also be tied, as otherwise the collateral circulation will allow blood to escape into the remains of the sac. It is well, also, to dissect out as much of the sac as possible.

This operation for false aneurysm has also been practised in situations where the vessel cannot be controlled on the proximal side of the sac. In such a case, after the sac has been exposed, an opening is made into

the aneurysm barely large enough to admit the finger, which is immediately thrust into the interior so as to form a plug to check the escape of blood; the finger is gradually insinuated through the clots, and the opening in the vessel is made out by the sense of touch or by feeling the stream of blood impinging on the finger as it escapes from the vessel. The opening is firmly compressed against the underlying bone, and then the sac is laid freely open, the clots turned out, and the artery cleared and tied above and below, while the pressure is maintained. In some cases of false aneurysm it may be possible to perform Matas's operation (see p. 182).

In cases of subcutaneous rupture of an artery in which the patient does not die at once but a **diffuse aneurysmal hæmatoma** forms, the treatment is to compress the artery above, cut down upon the hæmatoma, clear out the clots and tie the vessel above and below the seat of injury. The wound is then stitched up, but it is well to put in a drainage tube for the first few days, as there is generally a good deal of oozing. When the main artery of a limb is affected, the limb should be kept warm and elevated; the general treatment is similar to that called for after ligature for true aneurysm.

ARTERIO-VENOUS ANEURYSM.

In connection with false or traumatic aneurysm must be considered another condition sometimes met with, in which there is a communication between an artery and a vein—that known as arterio-venous aneurysm. This also is the result of direct injury in the great majority of cases, although instances have been met with in which the communication has formed without any traumatism. There are two forms of arterio-venous aneurysm, namely, **Varicose Aneurysm,** in which an aneurysm (usually a false one) communicates with a neighbouring vein; and **Aneurysmal Varix,** in which there is a communication between an artery and a vein without any intervening aneurysmal sac. The result of the communication in both cases is that arterial blood passes into the vein; this interferes with the return of the venous blood and renders the latter partially arterial. As a consequence the veins below the point of communication with the artery become dilated and elongated and practically varicose, while the result of the arterialisation of the venous blood, if excessive, is manifested by irregularity of the heart's action.

Aneurysmal varix is not a source of special danger, and may persist throughout life without serious results. The veins below the communication become varicose, the limb becomes swollen, there is a disagreeable thrill in the part, and the nutrition of the limb is interfered with; there is, however, no tendency to rupture.

In varicose aneurysm, however, this tendency undoubtedly exists, although not to the same extent as in true aneurysm; the aneurysm increases in size very slowly, and may ultimately burst. Hence, it is

essential to do something for varicose aneurysm if possible, and it is advisable to treat aneurysmal varix, but in the latter case operation cannot be urged as being a matter of life and death.

TREATMENT.—**Of Aneurysmal Varix.**—When the communication between the artery and the vein is in an accessible region, the treatment must be operative if a cure be desired; the exact procedure will depend upon the particular vessels involved. In the most usual case, namely, a communication between the brachial artery and the median basilic vein at the bend of the elbow, the best treatment is to ligature both the artery and vein immediately above and below the point of communication (see Fig. 61, *A*). In this way the disease is cured without opening and dissecting out the communicating part. When a large vein, such as the femoral, is involved, it is sufficient to tie the artery above and below the communication together with any branches springing from the main trunk between the ligatures, which should be placed as near the orifice of communication as possible; the vein may be left untouched. This is a matter of considerable importance in a vein such as the femoral, as ligature of it might cause œdema or even gangrene of the limb, and lead to a long and tedious convalescence.

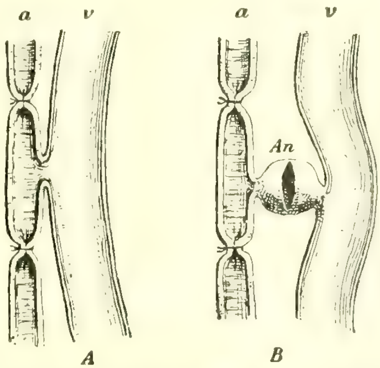


FIG. 61.—DIAGRAM SHOWING THE METHODS OF TREATMENT FOR ANEURYSMAL VARIX AND VARICOSE ANEURYSM. *A*, Treatment of an aneurysmal varix by ligature of the artery (*a*) above and below the communication with the vein (*v*). *B*, Treatment of a varicose aneurysm by ligature of the artery above and below, and incision of the aneurysm. In neither case need the vein be tied.

Of Varicose Aneurysm.—In all cases situated below the middle of the thigh or the upper arm the artery should be ligatured above and below the opening of the aneurysm; then the sac should be incised and the clots turned out. If possible the sac should be dissected away and the opening into the vein sewn up with a very fine round needle and the finest silk passed through sterilised vaseline (see p. 163). If it should be impossible to remove the sac entirely, however, any arterial branches coming from it should be ligatured and as much as possible should be dissected away, and the remainder sewn up, the aperture into the vein being occluded first by a suture similar to that used in Matas's operation (see p. 182). This leaves the circulation in the vein unimpaired. If the vein be small and unimportant it should be ligatured also, and then the whole aneurysm may be dissected out. The ligature of the branches is not always easy owing to the matting of the tissues, and it is one of the advantages of opening the sac that one can often see the openings of these branches and thus can trace them.

When the affection involves the larger vessels, it may be possible to obliterate the aneurysm by means of one form of Matas's operation (see p. 182) and thus maintain the lumen of both artery and vein unimpaired. Even should thrombosis occur in the artery subsequently, time may be gained which will help the collateral circulation. Both the artery and vein must be temporarily controlled on both sides of the aneurysm. Even should it be absolutely essential to tie such important vessels as the femoral artery and vein simultaneously, gangrene will not occur if the wound be kept aseptic, but marked and prolonged œdema of the leg may result, and therefore ligature should be avoided if possible.

When the vessels involved are the first part of the subclavian, or the lower end of the common carotid artery with their accompanying veins, it is advisable to leave matters alone. The chances of rupture are not great, and it will usually suffice to protect the parts from violence and to treat any symptoms of cardiac irregularity by suitable medicinal means.

TRUE ANEURYSM.

CAUSES.—In true aneurysm the wall of the sac is in the first instance formed by one or more of the arterial coats. When the aneurysm is large, the remains of the coats of the artery become practically unrecognisable in the wall of the sac, which is then formed solely of condensed cellular tissue. Before a true aneurysm can be produced, disease or injury must weaken the wall of the vessel at the spot where the dilatation is to occur; this generally takes the form of chronic endarteritis or atheroma. When an atheromatous patch bursts into an artery, the blood finds its way into the little ulcer thus formed and brings about gradual expansion of the arterial wall. In other cases, the atheromatous process extends to the middle coat and dilatation ensues without any rupture of the internal coat; as a rule dilatation does not occur until the middle coat becomes weak. A similar weakening of the middle coat may result from contusions or strains of the coats of the artery which rupture fibres of the middle coat; the result is cellular infiltration of the coat in the vicinity followed by the formation of cicatricial tissue and dilatation of the weakened part.

The detachment of infected portions of the valves or clot in ulcerative endocarditis is liable to be followed by a softening of the arterial wall at the place where the embolus is arrested, and to lead to an aneurysm. Multiple aneurysms in young people are generally due to this cause.

In whichever way the damage be done, the weakened wall gradually dilates, until ultimately there is a cavity communicating with the vessel by an orifice of variable size; this is known as a sacculated aneurysm. The lining membrane of this cavity loses its smooth healthy character, and the blood-stream in it is more sluggish than in the vessel itself; the result

is that clot forms on the wall, and, as time goes on, becomes decolorised, adherent to the wall, and in part organised. After a time the clot presents a laminated appearance ; this often results from the blood finding its way either between the original layer of clot and the sac wall or into the substance of the white clot. Thus an aneurysm which has existed for any length of time will often contain masses of clot arranged in layers and spoken of as laminated clot ; this clot usually consists of alternate layers of red and white clot. Coincidently with the formation of laminated clot in the aneurysm, the wall of the aneurysm becomes steadily dilated, and the surrounding tissues partly atrophy as the result of pressure, and partly become condensed as the result of inflammation.

It is important to remember that the endarteritis which leads to the formation of an aneurysm is not limited to the actual spot at which the aneurysm occurs, but is usually diffused over the wall for a considerable distance, and in the immediate vicinity of the aneurysm there may be, and frequently is, considerable general dilatation of the vessel. Aneurysms are not infrequently multiple and symmetrical.

As a result of the aneurysmal dilatation, the flow of blood through the artery beyond the aneurysm is delayed and sometimes considerably interfered with. As a consequence, branches which come off above the aneurysm become dilated, more blood flows through them, and their communications with branches below the aneurysm also become enlarged ; in this way a free collateral circulation is established. This is of importance both with regard to treatment and also with regard to the risks of gangrene, should the aneurysm become diffuse.

Another condition, which, however, hardly comes under the notice of the surgeon, seeing that it is limited to the aorta, is that known as *dissecting aneurysm*, in which the blood burrows between the external and middle coats of the artery for some distance and then finds its way back again into the general blood-stream at a point lower down in the wall of the vessel.

RESULTS.—*Spontaneous Cure.*—In some cases the *formation of clot* may go on until the aneurysmal sac becomes entirely filled up and a spontaneous cure results. Such an event is, however, comparatively rare. After the aneurysm becomes filled with clot, organisation of that clot goes on until ultimately only a fibrous nodule remains at the seat of the former aneurysm. An aneurysm is cured when the sac is filled by a mass of fibrous tissue ; the coagulation of the blood is only a stage in the process of cure. Perhaps the most common way in which spontaneous cure arises is when the sac bulges upwards along the course of the artery, and presses upon the latter above the aneurysm and diminishes, or, indeed, altogether arrests the flow of blood through it ; the result is that the cavity becomes completely filled with clot and ultimately obliterated. Spontaneous cure of an aneurysm may also result from *suppuration of the sac* and the discharge of its contents. This

very rarely takes place spontaneously, but in former times, when sepsis was frequent, it sometimes followed operations in the vicinity of the sac. Instead, however, of leading to a spontaneous cure of the aneurysm, suppuration in the sac may lead to a fatal termination from hæmorrhage, or from general septic infection, as the result of the escape of septic emboli into the lumen of the vessel.

Rupture.—Generally, however, the clinical history of an aneurysm is that it gradually increases in size, causes absorption of the tissues around until it reaches a free surface, and then bursts and leads to fatal hæmorrhage. Sometimes, however, it may rupture subcutaneously, and then death may ensue either from an extensive escape of blood into the cellular tissue, if this be very loose, or from gangrene of the parts below from pressure of the effused blood upon the arterial trunk and the collateral circulation. This condition is spoken of as *diffuse aneurysm.*

VARIETIES.—Two forms of aneurysm are generally met with, viz. (1) *sacculated aneurysm,* in which the dilatation occurs only on one side of the artery, and in which the sac communicates with the artery by a comparatively narrow opening; or (2) *fusiform aneurysm,* in which there is dilatation of the whole circumference of the artery, giving rise to a fusiform swelling. In this form of aneurysm there is not, at first at any rate, any formation of the laminated clot described in connection with sacculated aneurysm. The fusiform variety enlarges more slowly than the sacculated, although it follows the same course in the main; towards the end of its existence it may become sacculated owing to greater dilatation of one part of the wall than of another, or from a localised rupture.

SYMPTOMS.—There is an expansile tumour, pulsating synchronously with the heart and associated with a bruit. Much pain may be caused from pressure on sensory nerves surrounding the aneurysm, or there may be paralysis from pressure on motor nerves, and œdema of the limb if the main vein of the limb be pressed upon.

TREATMENT.—The treatment of true aneurysm may be medical or surgical. Medical treatment is confined to the internal form of aneurysm, that is to say, in one of the great cavities of the body; surgical treatment is employed wherever possible in external aneurysm. Surgeons are, however, occasionally called upon to treat aneurysms which are on the border line between internal and external, for example, aneurysm of the innominate artery. In these cases, medical treatment must always be employed, whether surgical treatment be carried out or not. It will be well to indicate briefly, therefore, the chief points in the medical treatment of aneurysm.

Medical Treatment of Aneurysm.—This has for its object the production of a condition of affairs which will favour the occurrence of coagulation in the sac and spontaneous cure of the aneurysm. This end is, of course, most likely to be obtained when the aneurysm is of the sacculated variety; it is hardly likely to occur when it is fusiform. The

first point of importance is to diminish the force and rapidity of the circulation, and for this object the amount of food taken, and more particularly the fluid part of it is much restricted ; the second point is to increase the coagulability of the blood.

Tufnell's Method.—The plan originally described by Tufnell is that most commonly employed, but its stringency is such that it can seldom be adhered to strictly for any length of time. The patient is confined to bed and is forbidden to make the slightest movement. He is put on a very limited diet with the object of diminishing the force of the circulation, and of rendering the blood more fibrinous and thereby favouring the deposition of clot. The diet Tufnell recommended consists of ten ounces of solid food in the 24 hours, and about eight ounces of fluid. This is given in three meals a day, which are ordered as follows : For breakfast, two ounces of bread and butter and two ounces of milk or tea ; for dinner, three ounces of mutton and three of potatoes or bread, with four ounces of claret or water ; for supper, two ounces of bread and butter and two of milk or tea.

The patient should be confined to bed upon this strictly limited diet for at least two months ; should improvement occur, it should be persisted in as long as the patient can tolerate it. This plan can seldom be strictly adhered to, and some relaxation of it, particularly with regard to the amount of fluids administered, soon becomes necessary. The thirst rapidly becomes intolerable, and in many cases all that can be done is to restrict the diet as much as possible without running the risk of depressing the patient unduly or exciting cardiac irritability.

Drugs.—Various drugs are also administered in order to increase the coagulability of the blood. The chief of these is *iodide of potassium* in large doses, commencing with fifteen grains three times a day and increasing rapidly to thirty or forty. *Chloride or lactate of calcium* in cachets of five to ten grains may also be given twice daily. Injections of four to five ounces of a 2 per cent. sterilised solution of *gelatin* in normal saline solution have been used with the same object. The injection should be given deeply into the buttock or into the axilla beneath the pectoral muscles. It should be repeated every three or four days until pulsation in the sac ceases or it is evident that no good effect is likely to follow the treatment. Instead of a 2 per cent. solution, a 1 per cent. solution, using nine or ten ounces, may be employed. As many as eighteen or twenty injections may be required. Several successful cases following this method of treatment have been reported, but that there is considerable risk attending its use is evident from the number of deaths which have occurred from tetanus. Commercial gelatine is apt to contain the tetanus bacillus, and the difficulty in sterilising the solution is very great, as the efficacy of the gelatine is destroyed when the temperature is raised above a certain point. Before using the solution, it should be carefully tested to make sure that it is free from the tetanus bacillus ; a specially prepared gelatine may be

obtained. The fluidity of the blood may also be diminished by giving twenty grains of *compound jalap powder* three times a week, so as to produce copious watery evacuations.

Valsalva's Method.—In plethoric patients the method named after Valsalva, namely, the withdrawal of blood by frequent venesection (see Vol. I. p. 4) is recommended ; eight or ten ounces of blood are withdrawn daily for about the first ten days of the treatment, but this method must be used very carefully, and is not to be recommended for the majority of patients, especially those who are old or anæmic. In the latter *iron* is beneficial, and the administration of *opium* for the relief of pain produces a markedly good effect.

Surgical Treatment of Aneurysm.—The treatment to be followed in any particular case will depend largely upon the character and seat of the aneurysm. The following are the chief methods of treatment.

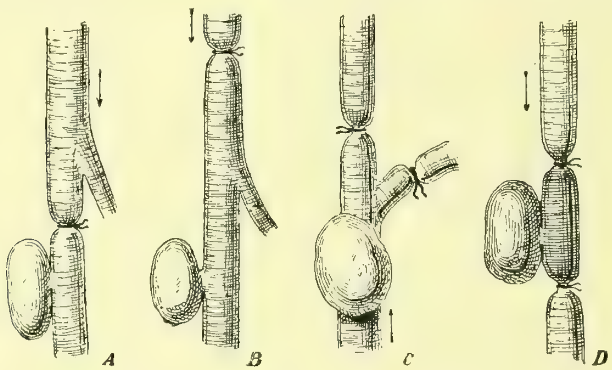


FIG. 62.—METHODS OF APPLYING A LIGATURE TO AN ANEURYSM.

A. Anel's operation.
B. Hunterian ligature.
C. Distal ligature—Brasdor's and Wardrop's operation.
D. The 'old' operation. The arrows show the direction of the blood stream.

(1) Ligature of the Artery affected.—This procedure may be divided into five different groups according to the site at which the ligature is applied, and the treatment of the sac of the aneurysm. They are :—

(*a*) *Ligature of the artery in close proximity to the sac* ; this is commonly known as 'Anel's operation' (see Fig. 62, *A*).

(*b*) *Ligature of the artery at such a distance from the sac that at least one branch intervenes between it and the ligature* ; this is usually known as the 'Hunterian operation' (see Fig. 62, *B*).

(*c*) *Ligature of the artery or its main branches on the distal side of the aneurysm* ; this is known as 'Brasdor's or Wardrop's operation' (see Fig. 62, *C*).

(*d*) *Incision of the sac, evacuation of the clots and ligature of the artery above and below the orifice of communication with the aneurysm* ; this is often spoken of as the 'old operation' (see Fig. 62, *D*).

(*e*) *Extirpation of the sac, with ligature of the vessel above and below.*

(2) **Endo-aneurysmorrhaphy** or obliteration of the orifice of communication between the artery and the sac by suture from within the sac. This operation is usually called Matas's operation.

(3) **Compression of the arterial trunk**, either *digital* or *instrumental*, which may be applied either on the proximal or the distal side of the aneurysm.

(4) **Galvano-puncture** by means of needles introduced into the sac and connected with the poles of a constant current battery.

(5) **Introduction of foreign bodies into the sac.**

Ligature of the Artery.—In applying a ligature to an artery for the cure of aneurysm, various points must be carefully attended to if success is to be obtained. The essential points are, firstly, the determination of the exact situation at which the ligature should be applied; secondly, the method of applying it; and, thirdly, the material of which the ligature should be composed. Special reference must also be made to the risks of secondary hæmorrhage and gangrene. After discussing these we shall proceed to describe the various operations for ligature in the order given above; we shall then describe the other methods of treatment.

The Point at which the Ligature should be applied.—Apart from the operation of opening the sac, turning out the clots and tying the artery above and below, the older method was to apply the ligature immediately above the sac—'Anel's operation.' As a result of this, secondary hæmorrhage frequently occurred, and suppuration in the sac was not at all uncommon. These accidents were at that time attributed partly to a diseased condition of the vessel at the seat of ligature, and partly to the direct irritation caused by the ligature upon the diseased vessel. Therefore, the modification of ligaturing the artery at a distance from the sac, known as the 'Hunterian operation,' was substituted. The object of this was partly to ligature the vessel where it was healthy, partly to avoid irritation in the neighbourhood of the sac, and partly to favour the deposition of firm laminated clot by allowing a certain amount of the circulation to be carried on through the aneurysm by the agency of the collateral branches. In other cases, when it was found impossible either to open the sac and tie the vessel on each side of the opening into it, or to apply a ligature on the proximal side, the artery has been tied on the distal side only—'Wardrop's operation.' The choice between the operation of proximal and distal ligature is practically determined entirely by the situation of the aneurysm and the possibility of applying the ligature on the proximal side. When proximal ligature is feasible it should be chosen in preference to the distal one.

The Force with which the Ligature should be tied.—This is a matter of some moment in the larger arteries, particularly the innominate, but in those of the size of the femoral downwards it does not seem to matter

provided that the ligature be tied sufficiently tightly to occlude the vessel. When a single round ligature is tightened, the internal and middle coats give way and curl up within the lumen of the artery, whilst the external coat remains constricted by the ligature. Hence, at first, the only obstacle to the escape of blood is this constricted external coat. Very shortly, however, blood-clot forms in the vessel, and this afterwards becomes organised and connects the divided internal and middle coats, while lymph is poured out and embeds the ligature, and later on organises and offers a still further obstacle to the escape of blood.

Some days or even weeks must elapse, however, before the organising material inside and outside the vessel is sufficiently firm to resist the high blood pressure which exists, for instance, in the innominate artery. Hence the view is held that in large arteries, such as the innominate, the ligature should not divide the internal and middle coats, but should only bring the walls of the vessel firmly together, and so occlude its lumen. As the ligature is tightened, the artery folds up in pleats, which come into absolute contact as the tightening is continued (see Fig. 63). It is only when the force is carried still further that rupture of the internal or middle coat occurs, but even without this, sufficient irritation results if the surfaces of the internal coat be brought firmly in contact by the ligature, and proliferation of the endothelium occurs, and leads to union between the opposed surfaces. While this is going on, the entire wall of the artery remains as a firm obstacle to the escape of blood, instead of only the external coat, as is the case when the two inner ones have been divided.

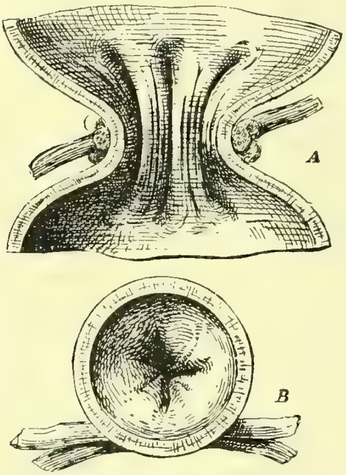


FIG. 63.—OCCLUSION OF AN ARTERY WITHOUT DIVISION OF ITS WALLS. *A* is a vertical section of a large artery thus tied, showing the pleating up of its walls. *B* shows the appearances presented on looking down upon the occlusion from above. (*Ballance and Edmunds.*)

Extensive experiments have been carried out by Ballance and Edmunds[1] as to the amount of force required to constrict a vessel without rupturing the internal coats, and also as to the exact method in which a ligature should be applied so as to occlude the lumen effectually without rupturing the coats. Naturally the amount of force varies according to the particular artery in question, and there is also a marked difference between that necessary to bring the walls into contact and that required to rupture the coats. The exact degree of force required under these

[1] *Ligation in Continuity.* London, 1891, Macmillan & Co.

circumstances in the large arteries has been accurately estimated by these authors, but in actual practice it can only be gauged by experience. As a matter of fact it is almost always possible to tell when the internal and middle coats rupture, as they can be distinctly felt to give way.

In large vessels such as the innominate it is very difficult to avoid a certain amount of relaxation of the first half of the reef or surgical knot at the moment of tying the second half when a single round ligature is used, and Ballance and Edmunds have therefore recommended that in its place two at least should be used, and should be applied in the following manner: The two ligatures are first passed around the vessel side by side, and the first loop of a reef or surgical knot is made in each separately in the same direction, but without constricting the vessel. The two ends of the ligatures on each side are then seized together and tightened simultaneously. In an artery such as the innominate, it will be found that with the ligatures so applied and tightened simultaneously instead of independently, it is as much as the surgeon can do to rupture the coats. Hence, if they be tied firmly until, as far as can be judged, the coats are well pressed together, the lumen of the artery will be obliterated without any risk of rupturing the coats. The knot is then completed by tying the two ends on each side together in the second half instead of separately as is done in the first half (see Fig. 64). There is no risk of a knot of this kind—which Ballance and Edmunds call a 'stay-knot'—undergoing relaxation as the second half of the knot is tied and therefore no channel is left in the artery through which blood can find its way.

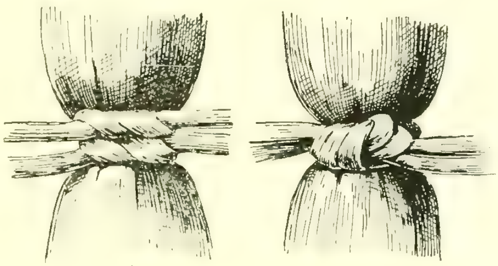


FIG. 64.—METHOD OF TYING A 'STAY-KNOT.' In *A* the first loop of two ligatures lying side by side on the vessel has been tied. *B* shows the mode of finishing the knot. The two ends on each side are seized together as one and tied into the second loop of the knot. (*Ballance and Edmunds*.)

The Material for the Ligature.—This should be very pliable, soft, and slowly absorbable. Absorption should take place in from three to six months. Of the various materials recommended we need only mention silk, catgut, and kangaroo tendon. Of these, *silk* is the most certain as regards the firmness of the knot and the slow absorption of the ligature, but at the same time it sometimes happens that it causes more irritation than is desirable, and the majority of surgeons therefore employ either catgut or kangaroo tendon. In the ordinary twisted or plaited silk a hard knot is formed, which is undoubtedly a source of irritation, and therefore if silk is to be employed, the soft floss silk ligature is the best, as it overcomes these objections almost entirely. Unless *catgut* be specially

prepared, it is apt to be absorbed too quickly, but with the firm, thick, chromic catgut which is at present on the market, three months or more may elapse before absorption is complete, and this material is sufficiently pliable and much less irritating than silk ; it can therefore be used safely for arteries of moderate size. *Kangaroo tendon*, which has come much into favour with many surgeons, has the disadvantage of being extremely slippery, and the first half of the knot is much more likely to relax during the tying of the second than when other materials are used. At the same time the tendon has the advantage of being a flat instead of a round ligature, and is probably, therefore, more suitable when it is desired to avoid division of the internal coats of the artery, for example, in the ligature of such vessels as the innominate ; a double ligature must always be used here in order to avoid relaxation. It is of the utmost importance that the ligature material should be rendered absolutely aseptic, as asepsis is the great point to be aimed at in avoiding any risk of separation of the ligature, and, therefore, of secondary hæmorrhage.

Risks of Ligature.—The chief of these are the occurrence of secondary hæmorrhage, and the risk of gangrene in the parts supplied by the ligatured artery.

Secondary hæmorrhage was frequent after ligature of the larger arteries in former days, when it was attributed variously to a diseased condition of the artery at the seat of ligature, to too free detachment of the sheath of the vessel at the point at which the ligature was applied, to too early separation of the ligature, or to too small an amount of clot within the vessel. When a wound is aseptic it is not essential that the vessel should be perfectly healthy at the seat of ligature, nor does the freedom with which the sheath is detached from the artery seem to matter much. Formerly in all treatises upon ligature of arteries the greatest stress was laid upon the necessity of making a minute hole in the sheath of the vessel, and gradually insinuating a fine aneurysm needle around it so as to avoid any risk of raising the artery from its bed. While, of course, it is well to avoid denuding the artery of its sheath more than is necessary, we have ample experience to show that the arterial sheath can be stripped off for a considerable distance in an aseptic wound without any risk of secondary hæmorrhage.

The real cause of secondary hæmorrhage in former days was septic infection of the wound, which necessarily entailed the separation of the ligature ; when silk ligatures become septic, they must be extruded from the wound like any other foreign body before healing can take place. The result is that the vessel in the immediate neighbourhood of this foreign body becomes inflamed and converted into granulation tissue, and suppuration ultimately occurs ; when this has taken place, the ligature becomes loose and can be pulled out. The only obstacle to the escape of blood from the vessel at this period is the granulation tissue into which the vessel wall has become converted, and the blood-clot deposited in the

interior of the artery. Should the granulation tissue be weak and the clot be small in amount, secondary hæmorrhage is very likely to occur. The amount of clot formed upon the distal side of the ligature is generally small, and it is from this and not from the proximal side that secondary hæmorrhage usually occurs. At the present day, when wounds are kept aseptic, ligatures do not separate at all; the wound heals rapidly, and there is very little formation of granulation tissue in the wall of the vessel, and consequently only slight softening of the coats. Moreover, the ligature becomes buried in lymph which undergoes organisation and thus serves to strengthen the artery. Hence the fear of secondary hæmorrhage after ligature of any artery, except perhaps the largest, such as the innominate, need not trouble the surgeon. Here however, there still seems to be a distinct danger of such an occurrence. This is due not to septic infection so much as to a mechanical rupture of the inner and middle coats, the external coat being too weak to resist the force of the blood-stream. The special precautions necessary in this case have already been outlined in speaking of the method of application of the ligature (see p. 177), and are referred to again in connection with ligature of individual vessels.

Gangrene.—The chances of gangrene after ligature of an artery in continuity depend upon the rapidity with which the collateral circulation is developed; this in its turn is influenced by two points. The first is whether the collateral circulation has been established before the ligature is applied: the second is whether it is possible for collateral circulation to be properly established. It may fail because of a diseased condition of the smaller arteries which prevents their proper dilatation or because of pressure exerted upon the collateral vessels as they arise from the main trunk or because of œdema of the limb, which will offer a physical obstacle to the circulation. Thus, the Hunterian operation is not the best in those cases in which the aneurysm is very large, in which there is extensive disease of the arteries or in which the aneurysm has become diffuse. Under these circumstances, and especially in the latter case, the clot may interfere seriously with the secondary circulation, and therefore the modern operation of opening the sac, clearing out the clots, and occluding the circulation through it either by Matas's operation of endo-aneurysmorrhaphy (see p. 182) or by tying the vessel above and below and extirpating the sac itself is less likely to lead to gangrene than is the Hunterian operation. When the aneurysm has become diffuse, the clots which are infiltrating the tissues should be removed at the same time.

Anel's Operation.—The views upon the question of applying the ligature in the immediate vicinity of the aneurysm, or at some distance from it, have undergone considerable alteration. It is now found that the opinion formerly held as to the diseased condition of the artery in the neighbourhood of the sac was not absolutely correct, and in a large number of cases the artery is quite as healthy close to the aneurysmal sac

as it is at some distance from it. Moreover, the risk of secondary hæmorrhage and suppuration in the sac is now known to be the result of sepsis and not of the irritation of the ligature. Hence the exact point at which the ligature should be applied depends more upon the anatomy of the part (particularly of the branches arising from the artery) and on the size and condition of the aneurysm, than on any other consideration ; we

Fig. 65.—Gangrene of the Leg after Obliteration of a Popliteal Aneurysm.
The patchy extent of the gangrene is well shown.

now apply the ligature at the point at which it iwill nterfere least with the blood-supply to the parts below.

The rules formerly laid down as to avoiding ligature of an artery in the immediate vicinity of a collateral branch, and the exact distance from the aneurysm at which it should be applied, are also of little value. Formerly it was found that when a ligature was applied in the immediate neighbourhood of a branch, the clot in the interior of the vessel did not extend further up than that branch, and, consequently, if the latter were

too close to the ligature, the amount of clot available for the prevention of secondary hæmorrhage was too small. Nowadays this is a point of no importance, because sepsis does not occur, the ligature does not separate, and, consequently, the size of the clot is immaterial.

The Hunterian Operation.—In this operation the artery is ligatured at some distance above the aneurysm. In the earlier operations done by John Hunter popliteal aneurysm was the affection treated, and the femoral artery was ligatured in Hunter's canal. At the present time the usual situation for the application of the Hunterian ligature for popliteal aneurysm is the apex of Scarpa's triangle, where the artery is superficial and readily accessible. After the vessel has been ligatured, pulsation in the aneurysm ceases, the blood comes to a standstill in the sac, and, being in contact with clot, undergoes coagulation. Changes then take place in the coagulum which lead to obliteration of the aneurysm and its conversion into a fibrous mass, which ultimately shrinks and almost disappears. While this is the usual result, it occasionally happens that the Hunterian operation fails to cure the aneurysm, particularly when the collateral circulation has developed freely before operation, and when, consequently, blood re-enters the artery below the ligature, and the circulation through the aneurysm is rapidly restored. It is not uncommon in popliteal aneurysm treated by the Hunterian ligature to find that pulsation recurs in the sac after two or three days from the establishment of the collateral circulation, but this gradually ceases, as a rule, and the aneurysm ultimately consolidates. In some cases, however, the amount of blood which passes into the sac is excessive, and the cure fails.

Distal Ligature.—The application of a ligature to the trunk of the vessel or its main branches on the distal side of the aneurysm is useful when neither the old operation nor the proximal ligature can be employed. It is, for example, specially suitable for aneurysms in which the vessel cannot be occluded between the aneurysm and the heart, such as those at the root of the neck, particularly the innominate, the first part of the subclavian or the carotid arteries, and it has been used in some cases of aneurysm of the arch of the aorta. The object of the procedure is either to arrest the current of blood circulating through the aneurysm entirely by cutting off the branches which emerge from it, or at any rate, to retard it to such an extent that the deposition of laminated clot can go on more rapidly and thus bring about a cure. On the whole, the results attending it are poor.

The 'Old Operation.'—In this operation the sac is opened and the clots are cleared out as completely as possible after the vessel has been ligatured above and below the orifice of communication. A recent addition to this operation is extirpation of the sac. This operation has come into favour for two principal reasons: in the first place it cures the aneurysm with certainty; in the second, it is less likely to be followed by gangrene than any other procedure in the case of a large

aneurysm or one which has become diffuse. In all cases of traumatic aneurysm in the extremities in which the circulation can be controlled by an Esmarch's bandage, it is the most satisfactory procedure.

In order to perform the operation in these cases, an incision is made over the aneurysm, extending well above and below the sac. The sac wall is exposed above, the artery is defined as near to the aneurysm as possible, and a ligature applied to it. The artery below the sac and any of the branches emerging from the sac are then sought for, and tied, and the sac is then laid freely open, and the clots turned out. Should there be any difficulty in defining the artery below the sac, assistance may be gained by passing a sound or bougie into its orifice through the sac. The sac is dissected out as completely as possible ; should any portion of it be adherent to the main vein or to important nerves in the neighbourhood, however, it should be left behind. This operation leaves a wound which will heal by first intention, the aneurysm is entirely got rid of, and the pressure it exerted on the collateral circulation (which sometimes increases as consolidation occurs) is entirely done away with. It is well to insert a drainage tube into the wound for three or four days.

Even for a traumatic aneurysm of vessels which cannot be controlled satisfactorily by an Esmarch's bandage, the operation may be performed if it be possible to ligature the vessel upon the proximal side before the sac is opened, as by this means the risk of serious hæmorrhage on opening the sac is largely avoided. If any blood escapes when the sac is opened, it will come from the lower end, or from some branch opening into the sac ; and should this happen, the finger should be placed over the aperture from which it comes, whilst the lower end of the vessel or any of the branches emerging from the sac are sought for, and tied. It is possible that the operation of endo-aneurysmorrhaphy (*vide infra*) may supplant this operation in some of these cases.

After-treatment.—After any operation for ligature of the main arteries of an extremity every precaution should be taken to diminish the risk of gangrene. The limb should be disinfected (see Vol. I. p. 100), wrapped in a thick mass of sterile salicylic wool and kept slightly elevated on a pillow, special care being taken to avoid pressure over any bony point such as the heel.

When extirpation of the sac or Matas's operation has been performed, the patient may be allowed to get up in about three weeks. After the Hunterian ligature, however, it is well to keep the patient in bed for six weeks or two months. There is often much pain as the sac contracts.

Endo-aneurysmorrhaphy or Matas's Operation embraces two distinct procedures. In one the lumen of the main artery is obliterated, while in the other an endeavour is made to maintain the circulation through the main vessel after effecting a radical cure of the aneurysm.

The former may be called the 'obliterative' and the latter the 'restorative' method, and each may be useful in special cases. Thus, in fusiform aneurysm the lumen of the vessel cannot be restored, and the obliterative method must be employed; while in a sacculated aneurysm the mouth of the sac involves only a small part of the arterial wall, and the aneurysm may, therefore, not only be cured, but the lumen of the vessel sometimes reconstituted by the restorative method.

The first step in both forms of the operation is to control the circulation through the aneurysm completely; unless this can be done the operation is so difficult as to be almost impracticable. When possible, Esmarch's bandage should be employed, as it commands the blood-supply completely, so that there can be no bleeding, even if vessels are given off from the sac. If the aneurysm be too high up in a limb for the bandage to be used, it will be necessary to expose the main artery above and below the sac, and control the circulation through it with a temporary ligature or with a Crile's clamp. The latter is, perhaps, the more useful, as it is not only easy to apply, but its pressure is uniform, whereas a temporary ligature may be held either too tightly or too loosely. When

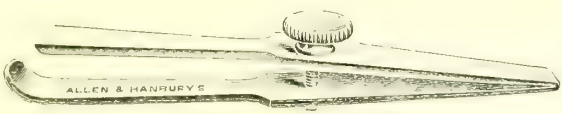


FIG. 66.—CRILE'S CLAMP FOR TEMPORARY HÆMOSTASIS. The blades should be sheathed in rubber tubing.

the blades of the clamps, which should be sheathed with rubber, are in position, they should be screwed down very slowly until the pulse in the vessel below disappears. The aneurysm should be exposed by an incision made in the line of the artery. The soft parts should not be separated from the sac, and only important anatomical structures should be avoided as the incision is deepened. The sac is then incised from end to end in the long axis of the tumour, the clot turned out and the cut edges of the sac fully retracted, so as to enable the surgeon to get a good view of the interior of the aneurysm. The number of openings is noted; in a fusiform aneurysm two circular orifices are seen, one at the upper and one at the lower end, while in the sacculated form the orifice is single and usually ovoid. When branches are given off from the part of the artery involved in the sac, there will be additional openings.

The Obliterative Suture.—Any clot adhering to the inner lining is removed with a piece of sponge or gauze from the neighbourhood of the orifices of communication between the sac and the vessel. Each orifice is then closed by a series of sutures inserted as shown in Fig. 67. Chromicised catgut is probably the best suture material, as it holds firmly and long enough for union to occur, and is eventually

absorbed. Fully curved, spring-eyed, round intestinal needles should be used, and the suture should be as thick as the needle will carry, so that it fills completely the hole made by the needle. The size of the needle and suture will vary with that of the artery to be sutured, and a needle-holder will be required. Interrupted or continuous sutures may be employed; the latter is probably the better, and each suture should be about one-eighth of an inch from its neighbour, and should be inserted through the inner wall of the sac about a sixth to a quarter of an inch from the margin of the orifice, and should then pick up the floor of the artery as it enters the sac; finally it is passed through the opposite margin of the aperture of communication (see Fig. 68). A sufficient number of sutures are introduced to occlude the opening completely. Each orifice is sutured separately, and the mouth of any branch given off from the aneurysmal sac is treated similarly. A second layer of sutures burying the first may be employed, but is not absolutely necessary. The later stages of the operation are common to the two methods (*vide infra*).

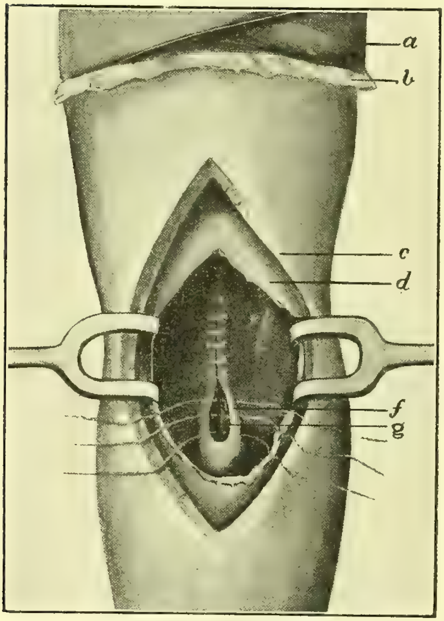


FIG. 67.—MATAS'S OBLITERATIVE SUTURE APPLIED TO A POPLITEAL ANEURYSM. (*a*) Tourniquet; (*b*) lint applied beneath the tourniquet; (*c*) divided edge of the skin and fascia; (*d*) sac of the aneurysm; (*e*) small vessel opening into the sac, sutured; (*f*) edge of the main vessel; (*g*) lower opening of the popliteal artery.

The Restorative Suture.—The object here is to approximate the edges of the opening, so as to cut off communication between the aneurysm and the artery without obliterating the lumen of the latter. The needle is entered well outside the edge of the aperture, but is brought out through its margin (see Fig. 69). It is then introduced through the margin on the opposite side and brought out some distance from the edge. This gives a firm hold and does not diminish the lumen of the vessel. A continuous suture is best. A second layer of sutures, which takes up the sac wall only and is external to this, may be used in order to secure still firmer apposition. It will be seen that in this method the first suture must lie in the blood-stream unless the approximation be perfect, and therefore the risk of thrombosis is considerable.

Obliteration of the Sac.—The steps of this part of the operation are

common to both methods. After the suture has been completed, the pressure on the artery is relaxed in order to see if there is any bleeding; if there is, the circulation is commanded once more and additional sutures are inserted. It is very important to obliterate the sac, so as to leave no cavity requiring drainage. The sac walls are approximated by stout sutures which are made to penetrate the deep wall of the sac, and are then passed through its outer wall and the skin over it together, and are tied over a pad of gauze. In some cases it may be possible to remove the superficial portions of the sac wall, leaving only the deeper parts to be brought into contact with the skin, which is sutured down to them.

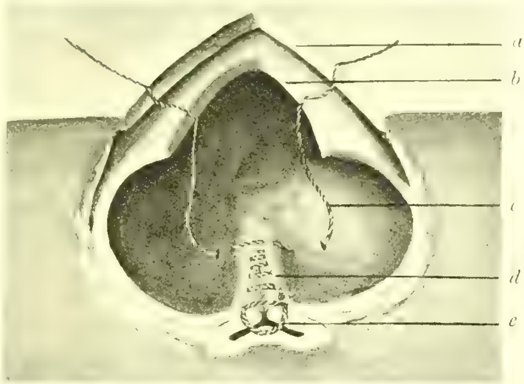


FIG. 68.—DIAGRAMMATIC TRANSVERSE SECTION THROUGH AN ANEURYSM TREATED BY MATAS'S OBLITERATIVE METHOD. (*a*) Cut edge of skin; (*b*) cut edge of aneurysmal sac which has been dissected away from (*a*) to a certain extent; (*c*) suture of second row; (*d*) edge of a vessel opening into the aneurysmal sac; (*e*) suture showing the method of obliterating the vessel.

Matas suggests that, in a fusiform aneurysm involving a very large vessel, it may be possible to perform a 'reconstructive' operation instead of the 'obliterative' one, when the wall of the vessel is not too much diseased, by suturing the artery wall over a piece of drainage tube, which thus acts as a mould. The tube is removed after all but the last few sutures have been inserted and tied over it (see Fig. 69). Thus there are really three distinct operations: (i.) The obliterative, (ii.) the restorative, and (iii.) the reconstructive

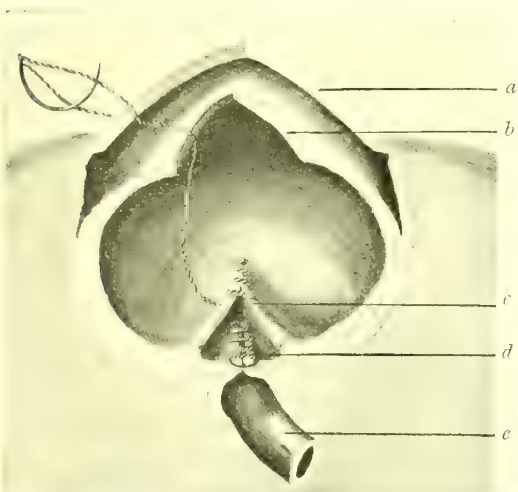


FIG. 69.—DIAGRAMMATIC TRANSVERSE SECTION OF AN ANEURYSM TREATED BY MATAS'S RECONSTRUCTIVE METHOD. (*a*) Cut edge of the skin; (*b*) cut edge of the sac; (*c*) second row of sutures; (*d*) first row of sutures; (*e*) rubber tube represented as projecting from the cut surface of the section.

The reconstructive operation is probably only suitable for aneurysm of the abdominal aorta or the upper part of the common iliac, as it is almost certain to be followed by thrombosis, and it is hardly worth while to do such a difficult operation except when it is of great importance to maintain the circulation, if only for a short time, in order to allow the collateral circulation to become established.

We have given the full details of this operation because it has been done already with a fair amount of success in a considerable number of cases, especially in America. It must be, however, difficult to perform successfully, and it is probable that further experience will show it to be only of limited applicability.

Compression. — The artery may be compressed either by the fingers or by special instruments. This method of treatment, which is now rarely resorted to, consists in applying pressure to the artery (if possible upon the proximal side of the aneurysm and at some distance from it) and maintaining that pressure either continuously or intermittently for twenty-four hours or longer. It has been found in practice that a number of aneurysms can be cured by pressure, even when applied intermittently. The objections to the procedure are, firstly, that it is difficult to compress the vessel satisfactorily; secondly, that it causes great pain to the patient; and thirdly, that there is risk of injury to the vessel itself at the seat of compression: aneurysms have developed later on at the point of pressure. At the present time, compression would only be occasionally employed in the treatment of femoral aneurysm.

Galvano-puncture.—This method is only resorted to when there is no chance of employing one of the previous ones. Hence it is generally confined to sacculated aortic aneurysms which project externally, or to large innominate aneurysms. Its object is to cause the deposition of clot in the sac by the direct action of the galvanic current on the blood. Several needles connected with the positive pole of a constant battery are introduced into the sac, while the negative pole is connected with a large wet pad applied to the skin in the vicinity of the aneurysm. The skin must be scrupulously purified before the needles are introduced, and it is best not to introduce both poles into the sac; a large amount of gas is disengaged at the negative, and the clot which forms there is soft, frothy, and useless; moreover, a considerable amount of heat may be generated, should the points of the needles come into contact. The clot formed at the positive pole is firm and of great use in the cure of the aneurysm, whilst the amount of gas disengaged is comparatively small. Only the finest needles should be employed, and they should be carefully insulated to within a short distance of their points; the uninsulated portion should be buried completely in the interior of the aneurysm, so that only the insulated part is in contact with the skin and the wall of the sac. Unless this be done, the naked portion of the

needle as it passes through the skin and the wall of the aneurysm may burn a hole in the sac, and the aneurysm may thus become diffuse. The needles should be disinfected by boiling ; they should not be immersed in strong carbolic solution, which destroys the insulating material. If more needles than one are introduced, they should be kept parallel to one another in order to produce the greatest effect. The strength of the current employed may be varied, but it should not be stronger than 50 milliampères to begin with, and it should be continued until the sac becomes firm under the finger, as it usually does in about a quarter to half an hour ; the needles may be then withdrawn and the punctures painted over with collodion. The operation may be repeated once a week if necessary, and no anæsthetic is required.

The Introduction of Foreign Bodies into the Sac.—This method was at one time largely employed with the object of producing clotting around the foreign bodies, the materials used being fine iron or silver wire or horsehair. In a certain number of cases success followed this method, but in others no cure was effected, although large quantities of the foreign body were introduced. In some cases the latter has been known to pass from the aneurysm into the general arterial system, and to have caused fatal results. The method generally adopted has been to introduce a considerable length of wire into the sac through a canula. After the wire has been passed into the cavity, the canula is withdrawn and the projecting end of the wire is pushed into the sac. After the canula has been removed, the aperture must be sutured or ligatured in order to prevent hæmorrhage taking place. Neglect of this detail has led to the death of the patient.

Cages of steel wire compressed into the form of a cylinder have also been designed[1] (see Fig. 70). When the wire is in position in the sac, it expands at once; one or more cages may be employed according to the size of the sac and the amount of clotting surface it is thought desirable to have.

Macewen's Method.—Instead of introducing foreign bodies into the aneurysm and leaving them *in situ,* Macewen has suggested the insertion of fine steel pins through the wall of the sac in such a manner as to scratch or scarify the wall on the opposite side over a considerable area, and thus to produce a rough surface upon which clot will be deposited. The pins should be of tempered steel, as fine as possible, and should taper to a point like the ordinary sewing needle ; on the opposite extremity is a rounded head. The skin and the pins are disinfected ; the pin or pins are then made to penetrate the sac and pass right through its cavity until the point is felt to come into contact with the opposite side, which it should be made to touch but not to penetrate. The point of the pin is then moved over the surface of the wall upon which it has impinged so

[1] D'Arcy Power and Colt, *Trans. Med. Chir. Soc.*, vol. lxxxvi. p. 363.

as to scratch it freely, and this should be done over as large an area as

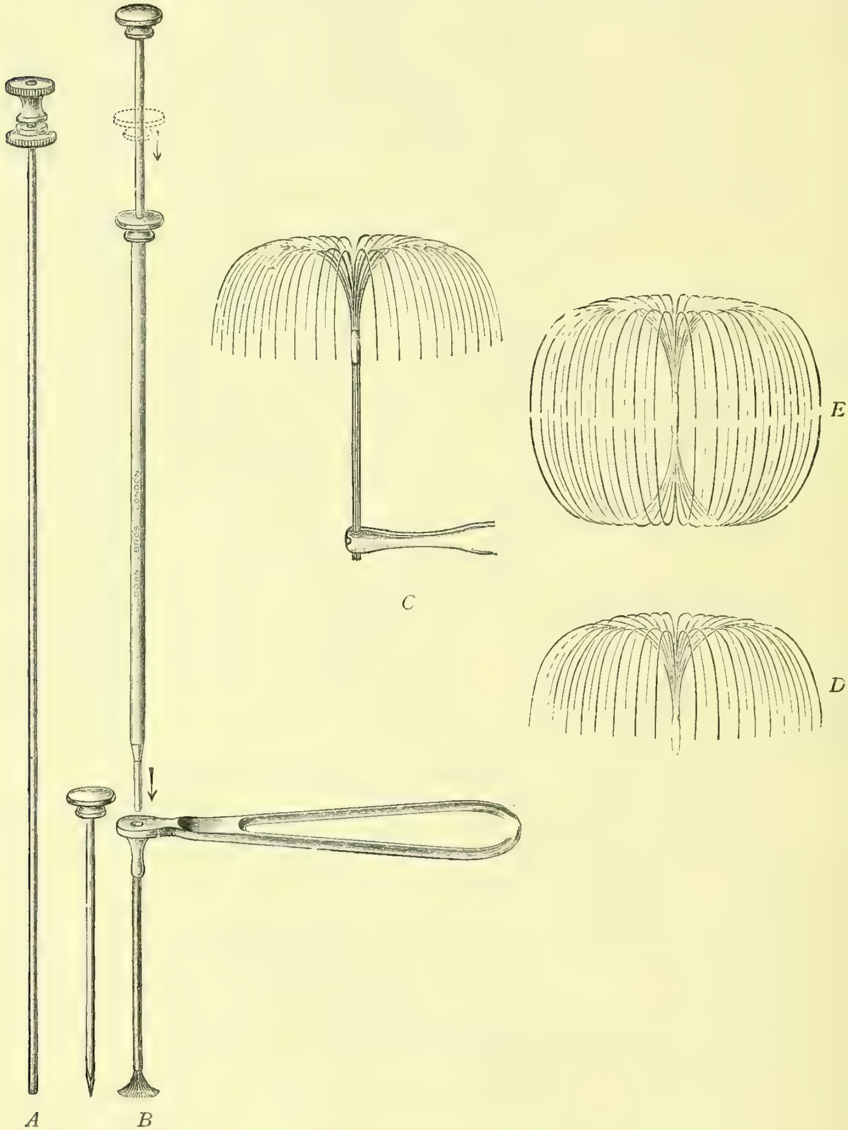


Fig. 70.—Colt's Wire Cage for the Treatment of Aneurysm. *A*, the trocar and plunger; *B*, the canula with plunger in position, after insertion of the cage in its collapsed condition; *C*, the cage expanded just before withdrawal of the canula; *D*, single, *E*, double cage expanded.

possible. Sometimes the blood current can be felt to move the pin about, and in that case it may be left *in situ*, so that its oscillations will automatically lead to the necessary scarifications of the wall (see Fig. 71).

Macewen recommends that the scarification should be carried out for about ten minutes at one spot, and then the position of the point of the pin should be shifted so as to do the same at another point; in this way the greater part of the sac wall should be gone over. To do this the pin need not be withdrawn from the puncture in the skin; it may be left in the aneurysmal sac for some hours, but the longest time that Macewen recommends is 48 hours. While *in situ* the pin should be surrounded with a piece of antiseptic gauze, and when it is withdrawn a small dressing is fixed on with collodion and kept in place for several days. Should the aneurysm be large, several pins may be introduced at different points, a suitable interval being left between each so as not to do too much damage to the wall at any one point. The action of this procedure is slow; sometimes it may be weeks before any noticeable thickening of the coats is made out. The pins may be introduced on several occasions; it is well to leave an interval of a week to a fortnight between each introduction.

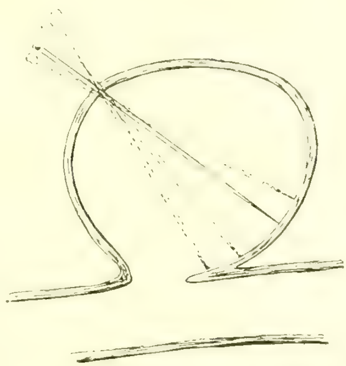


FIG. 71.—MACEWEN'S METHOD OF TREATING LARGE ANEURYSMS. The method is explained in the text. The dotted lines show the position of the steel pin as it is made to scarify fresh portions of the sac wall.

In several cases this plan has resulted in marked improvement; in one or two it has even produced an apparent cure of the aneurysm. In all cases, however, where either galvano-puncture or the introduction of needles is to be employed, it should be used at an early period in the disease before the sac has become too large and its coverings too much thinned.

SUMMARY.—It will be evident from what has gone before that in a **sacculated aneurysm** any of the above methods are applicable according to the circumstances of the case and the anatomical relations of the part. The precise indications for the choice of any particular method in any individual case is discussed in detail in connection with the various aneurysms. Wherever it can be employed, the best method is the radical one of removing the sac, and ligaturing the vessel above and below; Matas's operation may be performed when it is impossible to remove the sac. Failing either of these methods, the next best is Anel's, or the Hunterian ligature. When these are not applicable, distal ligature should be resorted to, and failing any of these we can only fall back upon galvano-puncture or the use of Macewen's needles or the employment of general medical treatment.

In cases of **fusiform aneurysm,** proximal ligature of the artery (or Matas's obliterative operation in certain cases) should be employed, except when the aneurysm involves a short extent of the artery and is

situated in the extremities; then, of course, it can be dissected out completely. Fusiform aneurysm, however, is comparatively rare in the extremities and there is little or no tendency in it to the deposit of clots upon the wall.

In **diffuse aneurysm** the radical operation should be employed whenever possible, on account of the risk of the compression exerted by the effused blood upon the collateral circulation producing gangrene of the limb, should the pressure not be relieved by the removal of the clots.

CIRSOID ANEURYSM.

By the term cirsoid aneurysm, or aneurysm by anastomosis, is meant a condition in which an artery or group of arteries is much enlarged, dilated, and tortuous. This forms a vascular mass consisting of numerous anastomosing branches, which may, in fact, be roughly described as an arterial nævus. The veins and capillaries in the neighbourhood are also enlarged in a similar manner. The affection may occur in almost any situation, but is generally met with about the head and face, especially in the area of the temporal artery and its branches, or upon the hand and lower part of the forearm.

There is generally free communication between the arteries and veins; the skin may become adherent to the tumour and ulceration may ultimately occur, and repeated and even fatal hæmorrhage ensue. Owing to the free communication with the veins, it may happen that there is considerable interference with the return of blood when the aneurysm is situated in an extremity.

TREATMENT.—This is often difficult. Ligature of the main arterial trunk leading to the aneurysm has proved almost uniformly futile. The method that offers the best prospect of success is *excision* of the tumour. The vessels entering and leaving the aneurysm are cut down upon and tied, and the tumour is then carefully isolated from its blood-supply, and dissected out. This operation is comparatively simple when the mass is small, but even then the number of vessels requiring ligature may be considerable. When the aneurysm is in one of the extremities, the operation is greatly facilitated by using an Esmarch's bandage. In the case of one on the head or face a temporary ligature should be applied to the external carotid.

When the tumour is large, the difficulties are increased enormously, and in some cases removal is impossible. Recourse may then be had to electrolysis (see Vol. I. p. 256), which should be applied whilst the circulation through the aneurysm is controlled by pressure upon the main artery leading to it; the electrolysis may be combined with ligature of the main artery.

In some cases about the wrist and palm in which the tumour threatened to rupture, it has actually been necessary to perform *amputation* of the limb.

CHAPTER XIII.

THE SURGICAL TREATMENT OF SPECIAL ANEURYSMS.

ANEURYSM OF THE THORACIC AORTA.

These aneurysms seldom come under the notice of the surgeon until they project from the wall of the thorax and threaten to burst through the skin.

TREATMENT.—All that can be done to reinforce the medical treatment is to promote coagulation within the sac by one of the methods already described—preferably **galvano-puncture** or the introduction of **Macewen's needles.** This, however, is seldom successful in arresting the progress of the disease completely. To some extent, no doubt, this is because the surgeon is seldom called in until a very late stage of the disease has been reached.

Distal Ligature.—Some degree of success has occasionally followed ligature of one or more of the large vessels of the neck for aneurysm of the arch of the aorta. Complete cure cannot be expected from this method, however, because the circulation through the aneurysm must remain free in spite of the operation. The vessels on the left side of the neck are usually tied, and the best success seems to have followed **ligature of the left common carotid.** In some cases the left **subclavian artery** has also been tied, either alone or in addition to the carotid; when it is decided to tie both vessels it is well to do it simultaneously. This operation is unsuited for cases in which there is valvular disease of the heart, in which the aneurysm is not definitely sacculated or is very large, and especially when it presses upon the bronchi.

ANEURYSM OF THE ABDOMINAL AORTA.

TREATMENT.—Here the aid of the surgeon is also sometimes sought. Compression of the abdominal aorta on the proximal side of the aneurysm is seldom feasible on account of the size and situation of the tumour, which most frequently occurs in the neighbourhood of the cœliac

axis, whilst distal compression has very rarely produced any beneficial result. Laparotomy has been performed several times for the cure of these aneurysms ; the sac has been filled with wire (see p. 187) ; or Matas's operation (see p. 182) has been done.

ANEURYSM OF THE INNOMINATE ARTERY.

Aneurysm of the innominate is not a common affection, and is not easy to diagnose. An aneurysm of the arch of the aorta, or of the lower part of the right carotid or subclavian arteries may readily simulate an aneurysm of the innominate trunk, and moreover, it should always be remembered that the dilatation of the innominate is often only a part of a general dilatation of the vessels. When the aneurysm is small, the situation of the tumour may assist the diagnosis. In an innominate aneurysm the swelling rises in the neck above the supra-sternal notch, whilst in an aneurysm of the first part of the carotid it usually appears between the sternal and clavicular heads of the sterno-mastoid muscle ; in an aneurysm of the first part of the subclavian it is on the outer side of that muscle. When the aneurysm is large, however, the swelling in each case occupies about the same position, and then the diagnosis is mainly made by observing the character of the pulsation in the terminal branches of the innominate. If the pulses in both the axillary and the carotid are delayed and feebler than on the opposite side, it is probable that the innominate trunk is affected, whereas if the pulses in these two arteries differ from one another, it shows that the aneurysm affects one branch of it only.

The aneurysm steadily increases in size and gives rise to pressure symptoms, chiefly manifested in the neighbourhood of the trachea. It enlarges upwards and forwards eroding the sterno-clavicular joint, and giving rise to a swelling at the root of the neck on the right side. It most frequently bursts through the skin, but rupture may take place into the trachea or the pleural cavity.

TREATMENT.—**Distal Ligature.**—Numerous attempts have been made to cure innominate or supposed innominate aneurysm by distal ligature, and these attempts have sometimes been followed by success in sacculated cases. The distal ligature is applied to the common carotid and the third part of the subclavian on the right side simultaneously. If an interval be allowed to elapse between the two operations, the collateral circulation is generally so far enlarged that there is comparatively little diminution in the flow of blood through the aneurysmal sac. In some cases it has also been found necessary to ligature the vertebral artery at the same time, but there is considerable risk attending the performance of this operation, as it interferes markedly with the cerebral circulation, which is already considerably diminished by ligature of the common carotid. It is, moreover, an extremely difficult operation, because the sac

gets in the way of the operator, and not only hinders identification of the vessel, but runs considerable risk of being punctured. On the whole, it is best not to attempt to ligature this vessel for an innominate aneurysm. When the aneurysm is of the *fusiform* variety these operations will do no good ; the best plan is to leave the patient alone.

Ligature of the Common Carotid Artery above the Omo-hyoid.—*Surgical Anatomy.*—On the right side the artery commences behind the sterno-clavicular articulation at the bifurcation of the innominate, while on the left it arises from the transverse part of the arch of the aorta. Each terminates at the level of the upper border of the thyroid cartilage; the left carotid is therefore somewhat longer than the right. The line of the artery in the neck is from the sterno-clavicular articulation to the mid-point between the angle of the jaw and the tip of the mastoid process.

Relations in the Neck.—*In front* are the skin, superficial and deep fasciæ, and the platysma throughout its whole length. The omo-hyoid crosses it at the level of the cricoid cartilage, and the lower part of the vessel is deeply placed, being covered by the sterno-mastoid, sterno-hyoid and sterno-thyroid muscles. The descendens hypoglossi nerve lies on the carotid sheath, though sometimes it is within it, and the artery is crossed by the sterno-mastoid artery, the superior and middle thyroid veins about its middle, and by the anterior jugular vein below. The communicating vein between the facial and the anterior jugular vein which lies along the anterior margin of the sterno-mastoid is superficial to the artery. *Behind,* the artery rests on the longus colli, the scalenus anticus, and the rectus capitis anticus major muscles. The inferior thyroid artery passes behind it at the level of the sixth cervical vertebra, and lower down are the vertebral artery, and on the left side the thoracic duct. The sympathetic nerve is behind the vessel throughout its whole length ; the vagus is behind and to its outer side. On the *outer side* is the internal jugular vein, which overlaps the artery in its lower part, especially on the left side. On the *inner side* are the trachea, the œsophagus, and the recurrent laryngeal nerve below, the pharynx and larynx above. The thyroid gland is internal to, and sometimes overlaps, the vessel.

The carotid sheath is derived from the deep cervical fascia, and contains the artery, the internal jugular vein and the vagus nerve, the latter being between the vein and artery, and on a plane posterior to both.

Operation.—Ligature of the common carotid trunk for innominate aneurysm is performed as follows: The skin is shaved and the patient lies on his back, with the shoulders raised on a sandbag so as to throw the head slightly back, with the chin towards the opposite side. An incision about three inches in length is made along the line of the artery, viz. in a line from the sterno-clavicular articulation to a point midway between the angle of the jaw and the mastoid process. The centre of the incision should be opposite the cricoid cartilage. The skin, platysma,

superficial and deep fascia are divided, and the sterno-mastoid muscle is pulled outwards. On dividing the deep layer of the deep cervical fascia, the omo-hyoid will be brought into view crossing the wound obliquely from above downwards and outwards. With regard to its effect upon the aneurysm, it is a matter of no importance where the ligature is applied to the carotid, and as it is easier to tie the vessel above the omo-hyoid, that is the point which is usually chosen. The omo-hyoid is therefore defined, the fascia enveloping it being divided in a direction parallel to its muscular fibres, and care is taken not to divide the descendens hypoglossi nerve which supplies it. The muscle is pulled downwards and inwards by a retractor; at this stage branches of the dilated superior and middle thyroid veins may require ligature. This exposes the carotid sheath, towards the outer side of which is seen the descendens hypoglossi. The artery lies in the inner compartment of the sheath, being usually overlapped by the jugular vein to some extent, varying with the distension of the latter (see Fig. 72). The exact position of the carotid can be determined by the pulsation; should this be diminished owing to the pressure of the aneurysm, its characteristic glistening white appearance and its flat ribbon-like feel will serve to identify it.

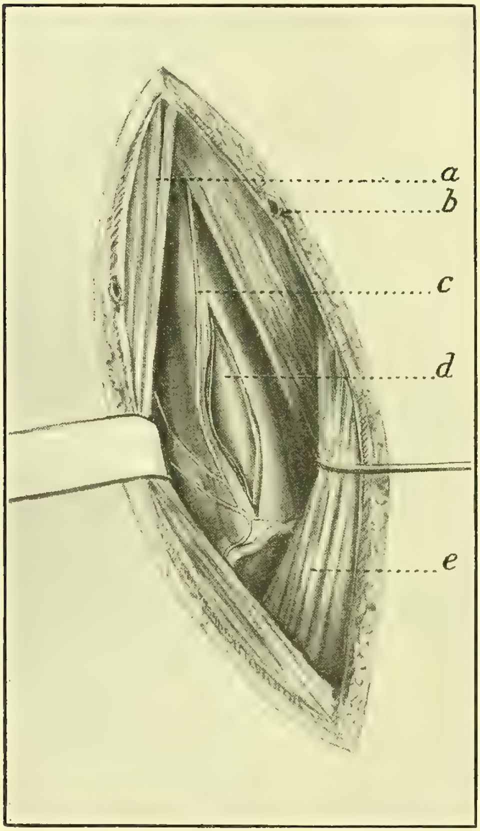


FIG 72.—LIGATURE OF THE RIGHT COMMON CAROTID ABOVE THE OMO-HYOID. (*a*) Sterno-mastoid muscle; (*b*) external jugular vein; (*c*) descendens hypoglossi nerve; (*d*) common carotid artery; (*e*) omo-hyoid muscle.

The carotid sheath is opened well to the inner side, so as to avoid the compartment containing the vein. A small portion is picked up with forceps and incised with the blade of the knife held on the flat, so as to avoid puncturing the vessel; the sheath of the artery is opened in a similar manner. The sheath is gently detached from the artery by insinuating between them an unthreaded aneurysm needle or a bent

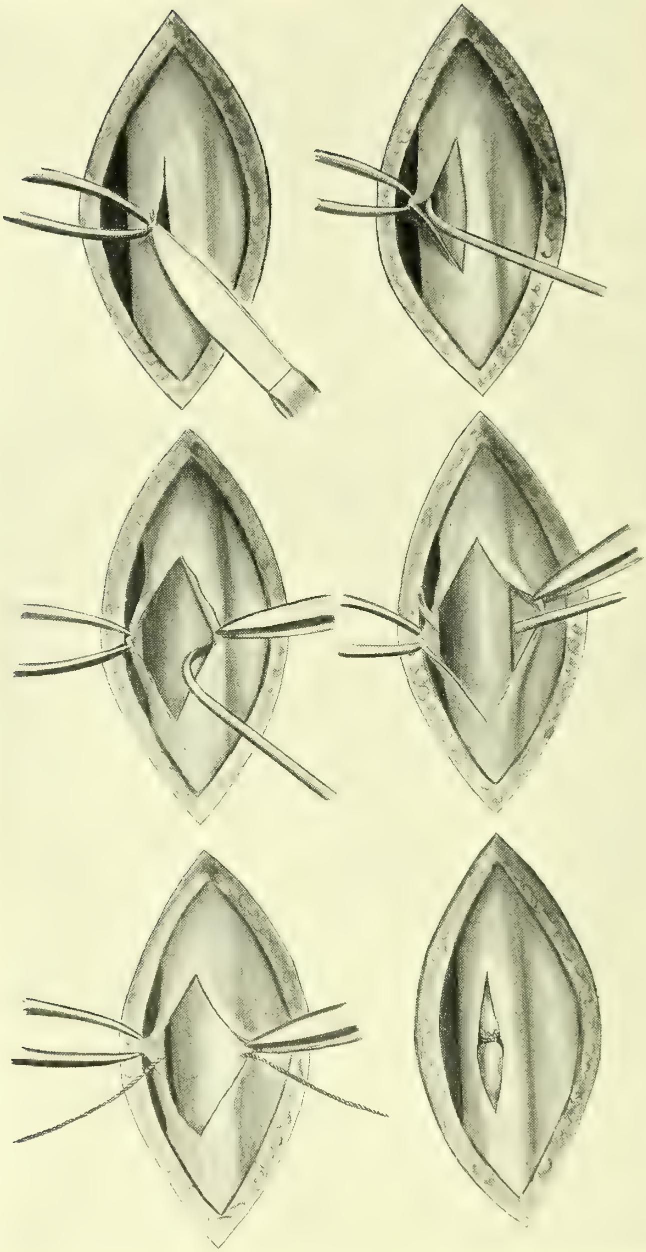


PLATE III.

THE VARIOUS STEPS OF CLEARING AND LIGATURING A LARGE ARTERY IN CONTINUITY.

The details of these are given on p. 195. All the stages. from incision of the sheath to the actual ligature of the vessel, are shown.

probe (see Plate III.). The best way to do this is to detach the sheath first on one side, whilst the corresponding edge of the incision in the sheath is steadied in forceps and then to treat the sheath on its other side in a similar manner until the needle is able to slip right round the vessel and its point emerges again through the opening. These manipulations must be carried out most gently and carefully, for it is easy to puncture the sheath and to wound the vein if force be used; and, moreover, carelessness may result in inclusion of the vagus in the ligature. The general rule is to pass the aneurysm needle from the outer side of the artery, so as to avoid puncturing the vein. The needle should be passed unthreaded; after it has been passed round the artery it is threaded with stout catgut or silk, and withdrawn.

Before the ligature is tied, care should be taken to see that nothing but the artery is included in it and that no injury has been done to the vein. Should the vein be punctured, it should be cleared for a short distance by enlarging the opening in its sheath, and the puncture may be picked up in a pair of forceps and a lateral ligature applied to the wall of the vein. Should the rent be too large to allow this to be done or should the ligature fail to hold properly, there is no objection to tying the internal jugular above and below the opening and dividing it between the ligatures. A single ligature is sufficient to occlude the common carotid, and the method of tying it has already been referred to (see p. 175).

Difficulties and Dangers.—This operation is usually quite simple; the chief trouble is bleeding from the branches of the superior or middle thyroid veins, which are dilated by the pressure of the aneurysm. The veins should be clamped between two pairs of pressure forceps before they are divided. Another difficulty is that the internal jugular may be so distended as a result of the interference with the venous return by the pressure of the aneurysm, that it overlaps the artery almost completely; this complication is best met by opening the sheath well towards the inner side. Wound of the vein and inclusion of nerves in the ligature are avoided by care in clearing the artery. When the thyroid gland is enlarged it should be pulled inwards.

The Collateral Circulation after Ligature of the Common Carotid.—The anastomosis of the branches of the internal carotids and vertebrals in the circle of Willis: the branches of the two external carotids and of the vertebrals across the middle line of the head and neck: the inferior thyroid with the superior thyroid: the deep cervical and superficial cervical with the occipital.

Ligature of the Third Part of the Subclavian Artery.—*Surgical Anatomy.*—This is the most superficial portion of the artery, and it extends from the outer border of the anterior scalene muscle to the outer border of the first rib. *Superficially* the artery is covered by the skin, platysma and fascia, and is crossed by the external jugular vein, which

receives the supra-scapular and transverse cervical veins. The nerve to the subclavius muscle and the descending branches of the cervical plexus cross it. The outer part of the artery is behind the clavicle and subclavius muscle, and is crossed from without inwards by the supra-scapular artery. *Above* the vessel are the brachial plexus and the omo-hyoid muscle. *Behind* it is the scalenus medius. The subclavian vein is in front of, and below the level of the artery. The lower end of the artery lies upon the outer surface of the first rib and the first digitation of the serratus magnus.

Operation.—The operation is done as follows. The patient lies on the back, with the shoulders supported on a suitable sandbag, the head turned towards the opposite side, and the arm firmly drawn down by an assistant or by a bandage fastened to the foot of the operating table. The clavicle is thus depressed, the posterior triangle enlarged, and the artery rendered more accessible. The soft parts are pulled down over the clavicle, and a transverse incision is made immediately over that bone, from the inner margin of the trapezius to the outer margin of the sterno-mastoid. The incision should go directly down to the clavicle and divides the skin, platysma, and the superficial cervical fascia. As soon as it is made, the skin is released, when the incision will be found to occupy the lower part of the posterior triangle, and in most cases to give sufficiently good access to the vessel. Should it be found that more room is required during the course of the operation, a vertical incision may be made upwards along the outer margin of the sterno-mastoid, taking care in doing this not to injure the external jugular vein; a triangular flap is thus formed, which is turned upwards, and stitched or hooked out of the way.

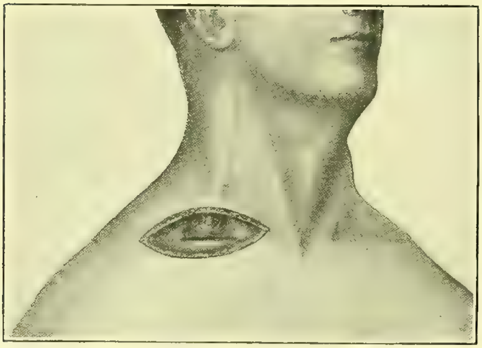


Fig. 73.—Ligature of the Third Part of the Right Subclavian Artery. *First stage.* Showing the opening made above the clavicle by the skin incision.

The tissues at the base of the posterior triangle are separated until the omo-hyoid muscle is seen crossing the space obliquely above the clavicle; the fascia along its lower edge must be divided in a direction parallel to the muscular fibres. The supra-scapular and transversalis colli veins and the termination of the external jugular vein will be seen running inwards beneath the posterior edge of the sterno-mastoid; they are usually very distended, and some of them must be divided between ligatures. The sterno-mastoid muscle with the fat and the veins beneath it are then drawn inwards, and the omo-hyoid upwards by means

of retractors. This exposes a triangular space bounded above and on the outer side by the omo-hyoid, on the inner side by the edge of the anterior scalene muscle, and below by the first rib, in which will be seen the cords of the brachial plexus above, and the subclavian artery below as it passes over the first rib. Below the subclavian artery, but separated from it by the anterior scalene muscle, is the subclavian vein, which should not, however, be seen during the course of the operation. Above and to the outer side of the artery is the lowest cord of the brachial plexus (see Fig 74).

The lowest cord of the plexus is clearly defined and the artery is

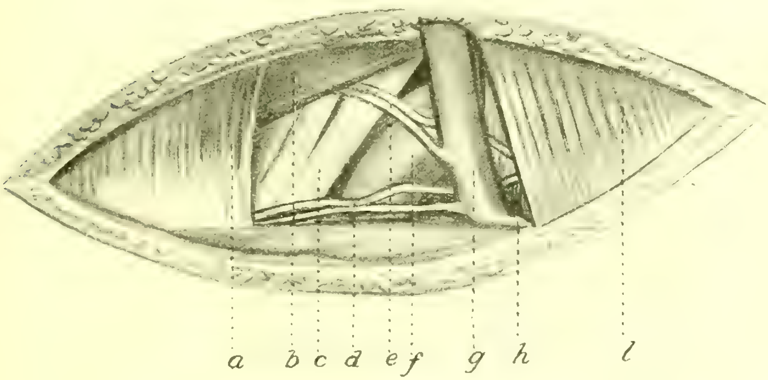


FIG. 74.—LIGATURE OF THE THIRD PART OF THE RIGHT SUBCLAVIAN ARTERY. *Second stage.* (*a*) Trapezius; (*b*) omo-hyoid; (*c*) cords of the brachial plexus; (*d*) supra-scapular artery and vein; (*e*) transversalis colli artery and vein; (*f*) subclavian artery; (*g*) internal jugular vein; (*h*) subclavian vein (this is only seen through a very small part of its extent in the corner of the wound); (*l*) sterno-mastoid muscle.

then seen lying parallel to, and on a deeper plane than, its lower edge. It is easy to verify this by feeling the pulsation in the vessel. After the vessel has been identified, the sheath is opened where the vessel lies upon the first rib, the opening seized with forceps, and a blunt probe, or, better, an unthreaded aneurysm needle insinuated between the sheath and the vessel. The needle is then withdrawn, threaded and passed around the vessel from before backwards and from below upwards, so as to avoid the possibility of puncturing the vein with the point of the needle. In order to do this, however, a specially constructed needle with a double bend, the second one corresponding to the bend of the clavicle (see Fig. 75) is necessary; otherwise the needle must be passed from above downwards. Some authorities recommend that the needle should always be passed in the latter direction in order to avoid inclusion of the lowest cord of the

brachial plexus. It should be easy to avoid doing this, however, if ordinary care be exercised in clearing the vessel.

After having tied the ligature, which should consist of a single thread of silk or stout catgut, the wound is stitched up without a drainage tube and sponge pressure (see Vol. I. p. 151) is applied over the base of the posterior triangle, so as to obliterate any cavity left. The arm should be wrapped up in cotton wool and bound lightly to the side for the first week or ten days; it should not be flexed at the elbow, but should lie on a pillow parallel to the trunk.

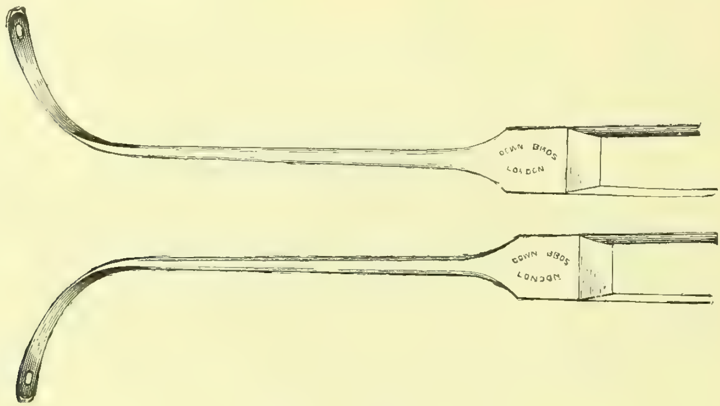


FIG. 75.—DUPUYTREN'S ANEURYSM NEEDLE.

Difficulties and Dangers.—Ligature of the third part of the subclavian artery is not easy even in the dissecting room, and in actual practice may be excessively difficult. The following are the chief difficulties in the operation. In the first place there is considerable *engorgement of the veins*, and this may be complicated by marked *œdema* of the cellular tissue, so that the surgeon may be confronted with a wound from which blood wells up copiously, and in which the normal structures of the part cannot be easily identified. It is of the greatest importance to have as bloodless a wound as possible; otherwise the difficulties in finding the artery are enormously increased. This is best assured by taking care that every vessel is clamped in two places, and, if necessary, ligatured before it is cut. Careful sponging and the sparing use of the point of the knife also facilitate matters greatly. The lower edge of the dilated external jugular vein may project well into the field of operation; it can generally be drawn inwards by a retractor, but should it get in the way, it must be divided between two ligatures. Care should be taken not to cut into it before it has been ligatured, as the cardiac end of the vein usually stands rigid and widely open as it passes through the fascia, and air may therefore be sucked into it. The arteries do not give rise to trouble as a rule. The transverse cervical is generally well above the incision, and the

supra-scapular usually lies behind the clavicle, well out of the way; should they come into the field of operation, they can be drawn aside with retractors, and should not be divided unless it is absolutely necessary, as they are important agents in carrying on the collateral circulation.

Perhaps the most important point in the operation is not to mistake *the lowest cord of the brachial plexus* for the vessel, as a ligature placed upon it would entail the most serious and painful consequences. This cord lies in close connection with the artery and is a good guide to it; in an œdematous and blood-infiltrated wound there is some danger of mistaking the one for the other, more particularly as the artery may communicate a spurious pulsation to the nerve. As long as the possibility of confounding the two is recognised, it should be easy to avoid such a mistake, as the firm rounded nerve cord is quite different to the feel of the flat, ribbon-like artery; besides which, the pulsation should be felt in the vessel, and digital pressure applied to it should at once stop the pulse in the artery below. The only other point that need be mentioned is the *necessity for keeping the needle close to the vessel* as the ligature is passed, and it is always best, where possible, to pass the needle round the artery from below upwards and from before backwards; the lowest cord of the plexus can be kept out of the way of the needle by a finger introduced as a guide into the wound. *Wound of the pleura*, which is usually described as a complication of the operation, need hardly be mentioned; it should never occur where ordinary care is employed, and even should it happen no serious harm results.

The Collateral Circulation after Ligature of the Third Part of the Subclavian Artery.—The branches of the supra-scapular and posterior-scapular anastomose with those of the acromio-thoracic and subscapular. The superior intercostal, the aortic intercostal, and intercostal branches of the internal mammary anastomose with the thoracic and scapular branches of the axillary.

ANEURYSM OF THE COMMON CAROTID ARTERY.

This affection is not at all common. It may be met with in any portion of the vessel, but is most frequent at the upper extremity close to its bifurcation, or at the lower end immediately above the origin of the carotid trunk. Its symptoms and course are similar to those of aneurysm elsewhere. The diagnosis is usually simple, but the affection requires to be distinguished from a tortuous condition of the artery, which is sometimes met with close to the bifurcation, and sometimes it may be confounded with glands, tumours, or abscesses which lie over the vessel and receive pulsation from it.

TREATMENT.—It is generally advisable to employ operative interference, the exact operation depending upon the situation of the aneurysm. *Digital compression* of the artery has been tried with success

in some cases, but is difficult to perform effectually; it causes great pain to the patient, and can only be continued for half an hour to an hour at each sitting. The pressure must necessarily be also exerted upon the vagus and is apt to give rise to serious cardiac symptoms. We do not, therefore, recommend its use. The pressure is made directly backwards by the fingers against the transverse processes of the fifth and sixth cervical vertebræ at the level of the cricoid cartilage (see Fig. 76).

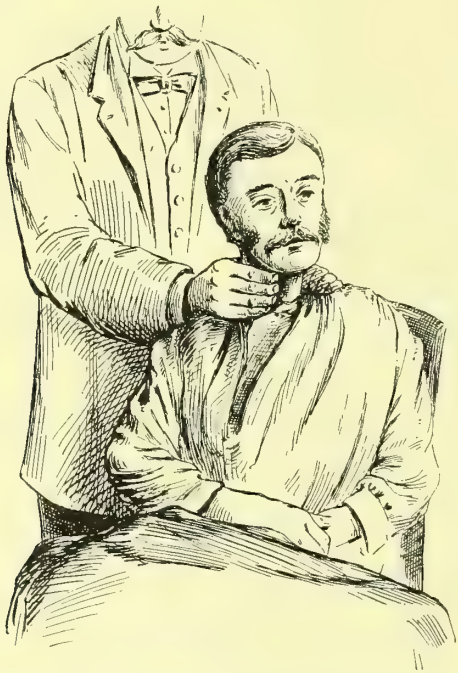


FIG. 76.—METHOD OF APPLYING DIGITAL COMPRESSION TO THE COMMON CAROTID.

Proximal Ligature.—This is the best method to employ in all cases in which the aneurysm is near the bifurcation. When, however, it is near the origin of the vessel, the distal operation must be performed, because the proximity of the aneurysmal sac and the disturbance to the soft parts caused by the aneurysm render ligature of the innominate artery impossible. When the aneurysm involves the bifurcation of the carotid, or is quite close to it, it is generally advisable to ligature the internal and the common carotid simultaneously, because the free anastomosis of the branches of the external carotid would otherwise tend to defeat the operation.

Ligature of the Common Carotid Artery below the Omo-hyoid.—The operation for ligature of the common carotid above the omo-hyoid muscle has already been described (see p. 193), but when the aneurysm

is situated at the upper part of the vessel, it is usually advisable to apply the ligature to the vessel below the point at which the omo-hyoid crosses it. In order to do this, the patient is placed in the same position as for ligature above the omo-hyoid, and an incision about three inches in length is made in the line of the artery, commencing over the sterno-clavicular articulation and extending upwards to the level of the cricoid cartilage. In this incision the anterior jugular vein may be exposed; it should be seized with forceps in two places, divided between them, and secured by catgut ligatures. Sometimes the dilated inferior thyroid veins may get in the way; if so, they must be divided between ligatures. The inner margin of the sterno-mastoid muscle is defined, the deep cervical fascia incised parallel to it, and the muscle pulled outwards with retractors. The lower part of the sterno-hyoid and sterno-thyroid muscles will then come into view, and should be drawn inwards towards the middle line, the cervical fascia being incised sufficiently for the purpose. The omo-hyoid muscle is also seen and drawn upwards. This leaves a triangular space bounded by the omo-hyoid muscle above and externally, the sterno-hyoid muscle internally, and the sterno-mastoid muscle below and externally (see Fig. 77); in it the carotid sheath is exposed. Should the lateral lobe of the thyroid overlap the sheath, it must be freed and drawn inwards with a retractor. The artery is cleared and ligatured exactly as in ligature of the vessel above the omo-hyoid. Should the situation of the aneurysm necessitate more room, it can be obtained by detaching the sternal origin of the sterno-mastoid by means of a transverse incision running outwards from the lower end of the vertical one. The muscle

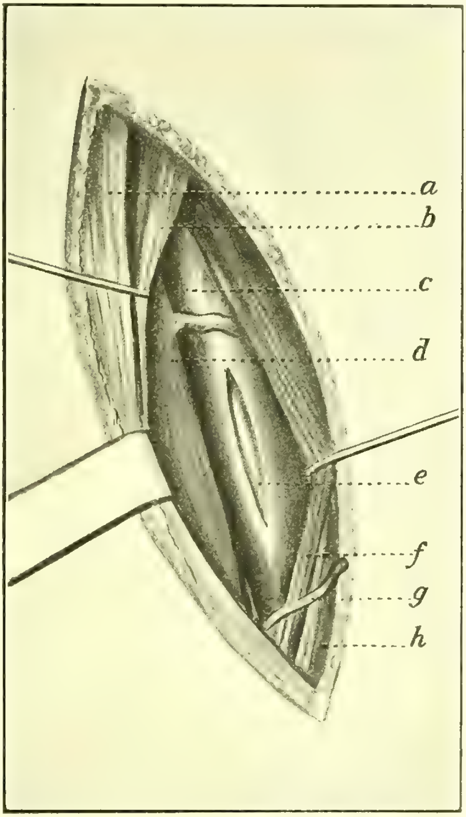


FIG. 77.—LIGATURE OF THE RIGHT COMMON CAROTID BELOW THE OMO-HYOID. (*a*) Sterno-mastoid; (*b*) omo-hyoid; (*c*) common carotid artery; (*d*) internal jugular vein; (*e*) incision in sheath; (*f*) sterno-hyoid muscle; (*g*) anterior jugular vein; (*h*) sterno-thyroid muscle.

is pulled outwards and, after the operation, is stitched in position with catgut.

Difficulties and Dangers.—Ligature of the common carotid, whether done above or below the omo-hyoid muscle, is always a serious procedure on account of the frequency with which cerebral complications follow it. When the artery is ligatured, the collateral circulation through the middle cerebral artery is often imperfect, and portions of the brain supplied by it may undergo softening; the consequence is that hemiplegia occurs in nearly 10 per cent. of the cases, frequently with a fatal result. If branches of the external carotid or the trunk of the internal carotid are also ligatured simultaneously, something like 25 per cent. of the cases suffer from hemiplegia, and of these nearly one-half are fatal. These cerebral complications may occur immediately after the application of the ligature, or they may not appear until after the lapse of 24 hours or more. Usually they begin in about twelve hours, the patient complaining of a feeling of giddiness and weakness on one side. This gradually increases and is generally accompanied by a considerable mental disturbance, which finally ends in coma and death.

The treatment of an aneurysm situated at the bifurcation of the common carotid by simultaneous ligature of the common and internal trunks may be an operation of the greatest difficulty, owing to the small space available above the aneurysm. The first step is to tie the common trunk on the proximal side of the aneurysm; this has the advantage that, unless there are many clots in the sac, the tumour will collapse sufficiently to enable the surgeon to get satisfactory access to the internal carotid, and it has the further advantage that, should the sac be ruptured during the manipulations necessary for ligature of the internal trunk, it will not be a matter of such great importance, as the sac can then be excised and the external carotid and its branches also tied.

Ligature of the Internal Carotid Artery.—*Surgical Anatomy.*—This artery commences at the bifurcation of the common carotid, and terminates in the middle fossa of the skull, where it divides into the anterior and middle cerebral arteries. In the neck it lies at first behind and on the outer side of the external carotid; as it ascends, it becomes internal to this vessel in the upper part of the neck as it passes beneath the posterior belly of the digastric.

The line of the artery is similar to that of the common carotid. *Behind* it rests upon the rectus capitis anticus major, the prevertebral fascia, the sympathetic trunk, and the superior laryngeal nerve. On its *outer* side are the internal jugular vein and the vagus. The spinal accessory and glosso-pharyngeal nerves are behind and to its outer side in the upper part of the neck; they lie between it and the internal jugular vein.

Internally is the external carotid artery below; higher up are the pharynx, the ascending pharyngeal artery, the superior laryngeal nerve and the tonsil.

In front are the skin, the cervical fascia, the platysma, the sterno-mastoid, the posterior belly of the digastric, the stylo-hyoid muscle and the deep surface of the parotid gland. The hypoglossal nerve and the occipital artery cross the internal carotid beneath the sterno-mastoid. Separating it from the external carotid are the stylo-glossus and stylo-pharyngeus muscles, the glosso-pharyngeal nerve and the pharyngeal branch of the vagus, the tip of the styloid process and the stylo-hyoid ligament.

Operation. —The position of the patient is the same as for the operation just described (*vide supra*). The incision is made parallel to and just over the anterior border of the sterno-mastoid, and should be about three inches in length, extending as low as the middle of the thyroid cartilage The platysma and the deep fascia of the neck are divided, the anterior margin of the sterno-mastoid muscle is defined, and the band of fascia running from it to the angle of the jaw is cut through. The muscle can be drawn outwards with a blunt hook, and the digastric muscle is seen above, with the parotid gland overlapping it, and the sterno-mastoid muscle on its outer side, with the spinal accessory nerve entering it above whilst the vessels are seen at the bottom of the wound, the external carotid lying in front of, and to the inner side of the internal (see Fig. 78). A careful examination of the vessels should be made to determine which one is giving off branches ; the internal carotid has no branches in the neck. The former vessel must then be drawn inwards. The sheath of the internal carotid is opened towards the inner side and cleared in the usual manner, care being taken not to injure the internal jugular vein which overlaps the artery. The needle is passed from without inwards so as to avoid the vein, and care must be taken not to include the vagus nerve. Should the aneurysm not have been injured during the operation, it is unnecessary to incise the sac unless it be of considerable size, and has caused much pain from pressure. In the latter case it is well to open it and clear out the contents, and either to ligature the external carotid beyond the sac and any branches given off from it, or to adopt one form of Matas's operation (see p. 182).

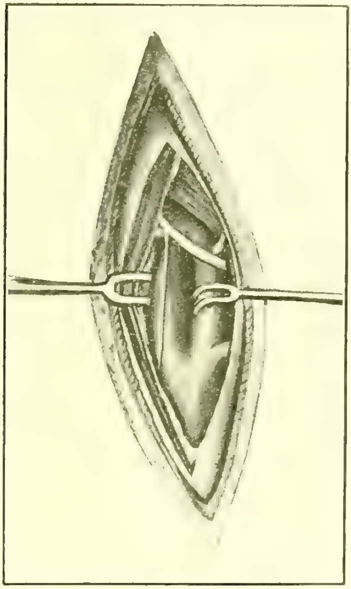


FIG. 78.—LIGATURE OF THE RIGHT INTERNAL CAROTID ARTERY. On the right the external carotid is retracted from the front of the internal carotid. On the left the sterno-mastoid and the various layers of the cervical fascia are held out of the way by a retractor. The hypoglossal nerve and its descending branch are seen superficial to the vessel.

The collateral circulation after ligature of the internal carotid is maintained through the circle of Willis.

Distal Ligature.—When the aneurysm is at the commencement of the carotid trunk, distal ligature above the omo-hyoid is the only operation that can be performed. The success of this is not nearly so great as that of proximal ligature ; there are the same risks of cerebral disturbance.

ANEURYSM OF THE EXTERNAL CAROTID ARTERY.

The external carotid is rarely affected except as the result of extension of an aneurysm of the common trunk ; aneurysm of this vessel is, therefore, usually situated just above the bifurcation of the common carotid. It may be situated somewhat higher up, however, and then shows itself as a swelling about the angle of the jaw. The pressure effects produced by it are not so severe as those of aneurysm of the common carotid, the most striking being those due to pressure upon the hypoglossal nerve.

TREATMENT.—The treatment of this affection should be ligature of the artery below the aneurysm, if possible. If the circulation can be controlled on both sides of the aneurysm, however, Matas's operation should be employed, because otherwise it would be necessary to tie the common and internal carotids simultaneously owing to the free anastomosis between the branches of the external carotid.

Ligature of the External Carotid Artery.—Ligature of the external carotid should be done between the origins of the superior thyroid and the lingual arteries. On account of the free collateral circulation it is also advisable to tie the more accessible branches such as the superior thyroid, the facial, and the lingual vessels at the same time.

Surgical Anatomy.—This artery commences at the bifurcation of the common carotid, and terminates in the substance of the parotid gland between the neck of the condyle of the lower jaw and the external auditory meatus, at which point it divides into the temporal and internal maxillary arteries. At its commencement the artery is superficial and internal to the internal carotid artery. The direction of the artery may be represented by a line drawn from the point of bifurcation of the common carotid to the front of the external auditory meatus.

At its origin the artery is *covered* by the skin, superficial and deep fasciæ, and the platysma, and is overlapped by the anterior margin of the sterno-mastoid muscle. In its upper part, it is deeply placed beneath the posterior belly of the digastric and the stylo-hyoid muscles, and in the substance of the parotid gland, where the temporo-maxillary vein descends on its outer side and the facial nerve crosses it. The lingual and common facial veins cross it, as they pass to the internal jugular vein. The hypoglossal nerve passes in front of the artery at the lower border of the digastric muscle.

Behind it are the stylo-glossus and stylo-pharyngeus muscles, the

glosso-pharyngeal nerve, the pharyngeal branch of the vagus, the stylo-hyoid ligament and the styloid process, these structures passing between the internal and external carotid arteries. The superior laryngeal nerve is behind both vessels.

On its inner side is the pharynx, the great cornu of the hyoid bone, and the superior laryngeal nerve and its branches.

Operation.—The neck is thrown well back over a sandbag and the head turned towards the opposite side. An incision is made over the line of the artery from the angle of the jaw to the line of the common carotid trunk opposite the upper level of the thyroid cartilage. A few superficial veins are secured, the deep fascia is opened, and the guides to the artery are felt for. The first is the greater cornu of the hyoid, above which the surgeon should make out the posterior belly of the digastric muscle (see Fig. 79). The cellular tissue is then separated with a blunt dissector, so as to expose the vessel, which can be traced from its point of origin upwards and inwards towards the posterior belly of the digastric; its pulsation can be easily felt. Crossing the artery from behinds forwards is the hypoglossal nerve which is a good guide, and must not be included in the ligature. The needle should be passed from without inwards, and care must be taken to keep it closely in contact with the artery so as to avoid taking up the superior laryngeal nerve.

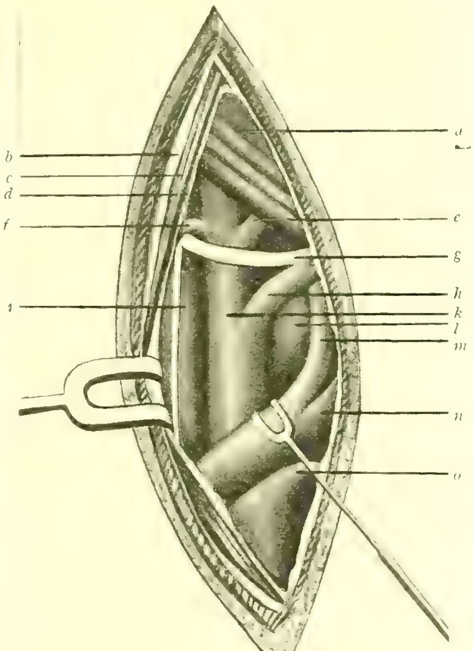


FIG. 79.—LIGATURE OF THE RIGHT EXTERNAL CAROTID ARTERY. (*a*) Digastric muscle; (*b*) superficial layer of the cervical fascia; (*c*) sterno-mastoid muscle; (*d*) deep layer of the cervical fascia; (*e*) facial artery; (*f*) occipital artery; (*g*) hypoglossal nerve giving off its descending branch; (*h*) lingual artery; (*i*) internal carotid artery; (*k*) external carotid artery; (*l*) great cornu of the hyoid bone; (*m*) facial vein; (*n*) lingual vein; (*o*) superior thyroid artery.

Collateral Circulation after Ligature of the External Carotid.—This is maintained by the branches of the opposite external carotid anastomosing across the mid-line of the head and neck with those of the ligatured vessel; by the terminal branches of the facial anastomosing with the

nasal and supra-orbital branches of the ophthalmic, and by the arteria princeps cervicis anastomosing with the branches of the vertebral and the deep cervical branch of the superior intercostal artery.

ANEURYSM OF THE INTERNAL CAROTID ARTERY.

The symptoms of aneurysm of this vessel are very similar to those occurring in aneurysm of the common trunk near its bifurcation, but the swelling is rather higher up in the neck, and the tumour projects beneath the mucous membrane of the pharynx, and indeed generally ruptures into the throat.

TREATMENT.—The treatment should be ligature of the internal carotid artery just above its origin if possible, and if not, the common and external carotid should be tied simultaneously (*vide supra*). A fatal result is very apt to occur in these cases from the cerebral complications already alluded to (see p. 202).

ANEURYSM OF THE SUBCLAVIAN ARTERY.

Aneurysms in this situation are more frequent on the right side than on the left, and are more common in men than in women. They mostly occur in the third part of the artery, but they may also be met with in the first part and still more rarely in the second. An aneurysm in the first part of the right subclavian artery is often associated with a similar condition in the trunk of the innominate, and the symptoms of these two forms are very similar. When the aneurysm occurs in the third portion of the artery it spreads downwards towards the axillary, and gives rise to pressure symptoms upon the brachial plexus and severe pain about the shoulder; there is also engorgement of the veins in the arm, with œdema from pressure.

TREATMENT.—The treatment has been very unsuccessful up to the present. Among the measures employed are ligature of the innominate, of the first part of the subclavian artery or of the axillary; amputation of the upper extremity; and various palliative measures, such as galvano-puncture, the introduction of needles, etc., which are employed when ligature in continuity is not feasible.

Ligature of the Innominate Artery.—Ligature of the innominate artery or the first part of the subclavian has proved almost invariably fatal from secondary hæmorrhage, but there seems reason to believe that this risk will not be so great in future. Ligature of the innominate artery is easier than ligature of the first part of the subclavian on account of the greater distance from the aneurysm; if the innominate be tied, it is well to tie the common carotid at the same time, as otherwise blood passes down the carotid into the subclavian and so on to the aneurysm.

Surgical Anatomy.—The artery arises from the right extremity of

the arch of the aorta, behind the middle of the lower part of the manubrium of the sternum. It ascends obliquely in the superior mediastinum to the upper border of the right sterno-clavicular articulation. It is one and a half to two inches in length. *Behind*, it lies on the trachea below, and the right pleura above. *In front* are the manubrium sterni, the sterno-hyoid and sterno-thyroid muscles, and the remains of the thymus gland. The left innominate and right inferior thyroid veins cross the artery near its commencement. On the *right* side are the right innominate vein, the vena cava superior, the vagus nerve, and the right pleura. On the *left* side are the thoracic portion of the left common carotid, the left inferior thyroid vein, and, at a higher level, the trachea.

Operation.—Ligature of the innominate artery, combined with a similar operation upon the common carotid, is performed as follows. The shoulders are raised on a sandbag, which throws the head and neck well back and brings the innominate artery to some extent up into the neck. It is essential for the success of the operation that the light should be good, and a powerful electric forehead light will be required in the later stages to illuminate the depths of the wound. It is most convenient for the surgeon to stand on the patient's left side, as a better view of the wound will be thus obtained. The incision should be made in the middle line, the advantage of this being that the muscles are then merely pulled aside ; after the operation they resume their place and leave no cavity behind, so that drainage is not necessary and primary union occurs rapidly —a point of considerable importance in these cases. The median incision also gives better access to the vessel than any other, and it is easy to tie the carotid artery through it also.

The incision commences at the cricoid cartilage, and extends down in the middle line to a little below the sternal notch. The skin, the cervical fascia, and often the communicating branch between the anterior jugular veins, are divided, and the handle of the knife is sunk into the division between the infra-laryngeal muscles. Some of the inferior thyroid veins which lie upon the front of the trachea and run downwards to the innominate, may require ligature and division ; the thyroidea ima artery, if present, will also require to be tied. If the muscles on the right side of the neck be now retracted firmly, the lower part of the carotid sheath comes into view ; if this be traced downwards, the bifurcation of the innominate will be felt. About half an inch of the innominate artery can thus be exposed in the sternal notch in spare subjects (see Fig. 80). The operation is greatly facilitated by clearing the upper part of the sternum and removing a piece from it about one and a half inches square by means of a chisel.

The sheath of the vessel is next opened as far down as possible, and rather to the left side of the artery; an aneurysm needle is carefully insinuated around it in the manner already described (see p. 194) and finally passed around the vessel from the outer side. Great care must

be taken to avoid puncture of the innominate vein which lies to the outer side and somewhat in front of the vessel, and aneurysm needles of varying curves and length must be at hand. Wound of the pleura is avoided by keeping close to the vessel.

The materials used for ligature of the innominate artery are floss silk or the ordinary Chinese twist, or kangaroo tendon which has been kept in a 1 in 1000 solution of perchloride of mercury in glycerine. Two ligatures should be applied side by side, and tightened up and tied in the

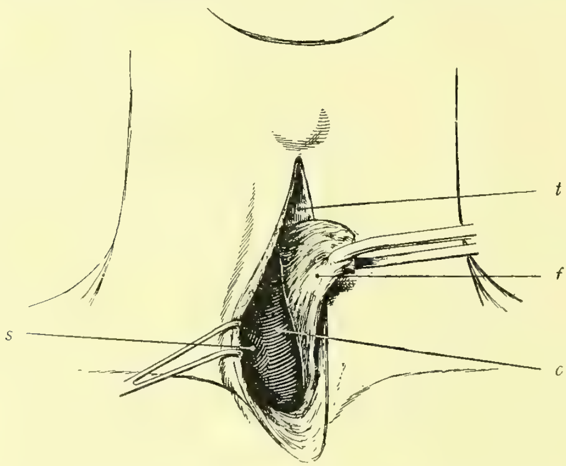


Fig. 80.—Ligature of the Innominate Artery through a Median Incision. The soft parts are pulled to the right after the interval between the sterno-thyroids has been opened up. The process of deep cervical fascia (*f*) covering in the vessels is seen pulled over to the left side in front of the trachea (*t*). This brings into view the innominate artery bifurcating into the common carotid (*c*) and the subclavian (*s*).

manner described on p. 177, care being taken not to divide the coats of the vessel in doing so.

Another incision for ligature of the innominate artery is a ⊥-shaped cut, one limb being parallel with the anterior border of the sterno-mastoid muscle, while the other runs outwards along the clavicle. The sternal origin of the sterno-mastoid and the attachments of the sterno-hyoid and sterno-thyroid muscles are divided. This method is undoubtedly superior to the preceding one in that it gives better exposure. The objection to it is that it creates a deep cavity in which blood may collect. Experience shows, however, that this is not so important now that wounds are kept clean, and it is probable that the practical advantage of having a clearly exposed field of operation in these most difficult cases will outweigh the rather theoretical one of faulty drainage. In this operation, as in the other, it is an advantage to remove the bone. The right sterno-clavicular articulation may be removed if desired, and the room will then be ample (see Fig. 81).

After the innominate artery has been tied, a ligature should be applied to the common carotid, close to its origin ; this can be done through the same wound. All hæmorrhage should be arrested by pressure and ligature before the wound is closed, and the muscles are allowed to fall back into their proper position or are sutured with fine catgut. It may be thought advisable to ligature the vertebral artery, but this is very difficult to do through a median incision unless the patient be very spare, and then it can only be done when the aneurysm does not bulge much towards the inner side.

The Collateral Circulation after Ligature of the Innominate Artery.—(1) Free anastomosis of the vertebrals and branches of the internal

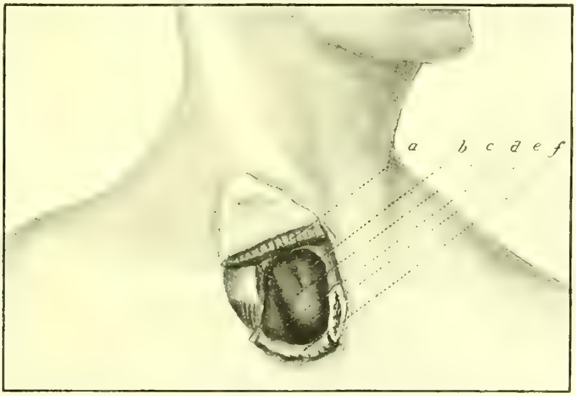


FIG. 81.—LIGATURE OF THE INNOMINATE ARTERY THROUGH A FLAP INCISION COMBINED WITH EXCISION OF A PORTION OF THE CLAVICLE. (*a*) Sterno-mastoid muscle, divided ; (*b*) common carotid artery ; (*c*) subclavian artery ; (*d*) innominate vein ; (*e*) innominate artery ; (*f*) lower portion of sterno-mastoid muscle. The right sterno-clavicular articulation has been excised.

carotids through the circle of Willis. (2) The branches of the two external carotids communicating across the mid-line of the head and neck. (3) The first aortic intercostal artery with the superior intercostal of the subclavian ; the aortic intercostals with the thoracic branches of the axillary and the intercostal branches of the internal mammary artery ; the deep epigastric with the superior epigastric of the internal mammary ; the phrenic with the musculo-phrenic branch of the internal mammary.

Ligature of the Vertebral Artery.—*Surgical Anatomy.* The vertebral artery springs from the upper and back part of the subclavian, opposite the interval between the scalenus anticus and the longus colli muscles. It terminates at the lower border of the pons, uniting with its fellow artery to form the basilar artery.

Relations in the Neck.—In the lower part of the neck the artery lies between the scalenus anticus and the longus colli, and enters the foramen in the transverse process of the sixth cervical vertebra. It is crossed

by the internal jugular and the vertebral veins, by the inferior thyroid artery, and by the terminal portion of the thoracic duct on the left side. It is surrounded by a plexus of sympathetic nerve fibres.

Operation.—The positions of the patient and the operator are the same as for ligature of the common carotid (see p. 193), except that the head is turned rather more forcibly to the opposite side. An incision three and a half inches long is made along the posterior border of the sterno-mastoid, extending upwards from the clavicle. The external jugular vein is avoided if possible, or divided between ligatures. The deep fascia is divided along the posterior edge of the sterno-mastoid, and that muscle and the internal jugular vein are drawn inwards together, the neck being flexed, meanwhile ; if necessary the muscle may be partially separated from its attachment to the clavicle. The artery is deeply seated, and the safest guide to it is the outer edge of the scalenus anticus, which is parallel to, but deeper than, the posterior border of the sterno-mastoid. The interval between the scalenus and the longus colli should then be identified, and the process of the sixth cervical vertebra felt for ; the artery can generally be found deep down beneath it. The needle should be passed from without inwards. The operation is difficult owing to the depth of the artery and the free oozing from the vertebral and other small veins which lie directly over the vessel ; if the former be wounded it must be tied. The wound must be widely retracted and a good light is essential. The fibres of the sympathetic are almost certain to be interfered with, and temporary contraction of the corresponding pupil usually occurs when the vessel has been secured.

Ligature of the First Part of the Subclavian Artery.—*Surgical Anatomy.*—The right subclavian artery commences behind the sterno-clavicular articulation at the bifurcation of the innominate artery, and on the left side the artery arises from the transverse part of the arch of the aorta. The right artery is about three, and the left about four inches in length.

Relations of the First Part of the Right Subclavian.—*In front* are the skin and fascia, the platysma, the sterno-mastoid, the sterno-hyoid and the sterno-thyroid muscles ; the anterior jugular, the internal jugular and the vertebral veins ; the vagus, the phrenic and branches of the sympathetic nerves, the sternal end of the clavicle, and the sterno-clavicular joint. *Below,* the recurrent laryngeal nerve intervenes between the artery and the pleural sac. *Behind* are the longus colli muscle, the neck of the first rib, and the transverse process of the first dorsal vertebra. The subclavian vein is below the level of, and on a plane anterior to that of the artery.

Relations of the First Part of the Left Subclavian.—In the superior mediastinum this vessel ascends almost vertically to the root of the neck, where it curves upwards and outwards to the inner border of the scalenus anticus. *Behind* are the œsophagus, the thoracic duct, the

longus colli muscle, and the inferior cervical ganglion. *In front*, and to its right are the left common carotid artery, the left vagus, the cardiac branch of the sympathetic and the phrenic nerves. The left innominate vein crosses it obliquely, and the left lung and pleura overlap its outer side. The left vagus crosses the lower part of the artery. On its *inner side* are the trachea, the œsophagus, the recurrent laryngeal nerve and the thoracic duct. On its *outer side*, it is closely applied to the pleura.

At the root of the neck, the internal jugular, vertebral and subclavian veins, the sterno-thyroid, sterno-hyoid, and sterno-mastoid muscles, and the phrenic nerve are superficial to it, and the thoracic duct passes obliquely across it.

Relations of the Second Part of the Artery.—On both sides this part of

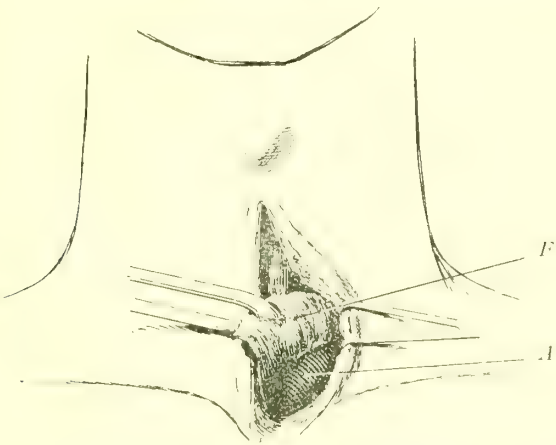


FIG. 82.—LIGATURE OF THE FIRST PART OF THE LEFT SUBCLAVIAN THROUGH A MEDIAN INCISION. Here the soft parts are pulled over to the left. (*F*) Deep cervical fascia. (*A*) subclavian artery.

the artery lies behind the scalenus anticus, which separates it from the subclavian vein, which is on a lower level, and also from the phrenic nerve. More superficially, the sterno-mastoid and platysma cover the vessel, and in the subcutaneous tissue the anterior jugular vein passes outwards in front of it. *Behind* and *below* is the pleura ; *above* is the brachial plexus.

Operation.—In aneurysms of the third part of the *left* subclavian artery the first part of the vessel may be reached by a median incision, and a ligature applied to it immediately after its origin from the aorta, as it lies to the left of the trachea, and before it gives off any branches (see Fig. 82). It may also be reached further out by a vertical incision between the two heads of the sterno-mastoid muscle, and from this incision it may be tied either close to, or beyond the origin of its branches. On the *right* side the first part of the subclavian may be exposed and tied by a vertical

incision between the two heads of the sterno-mastoid muscle. The patient is placed upon his back with the shoulders raised by a sand-bag, and the head turned to the opposite side. The interval between the clavicular and sternal heads of the sterno-mastoid is identified, and an incision is made over it parallel to the long axis of that muscle, about four inches in length, and with its centre about an inch above the clavicle. After the fascia has been divided, the interval between the two heads of the muscle is made out, the tissue filling it is opened up, the muscle split upwards as far as may be necessary, and the two portions held aside by retractors. Immediately beneath the fascia connecting the two heads of the muscle will be found the sterno-hyoid muscle at the inner

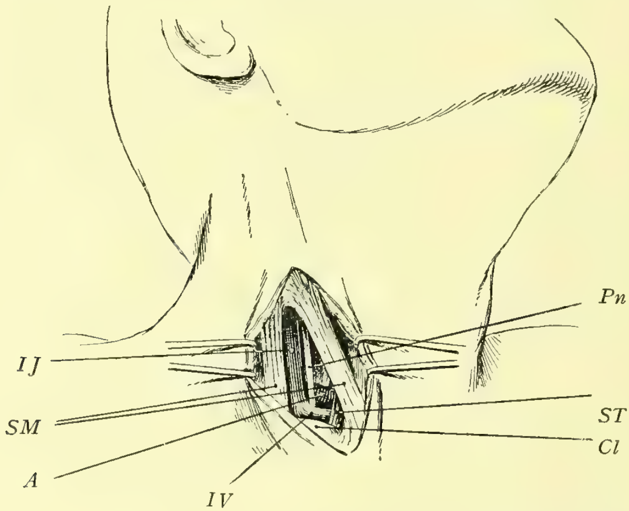


FIG. 83.—LIGATURE OF THE FIRST PART OF THE RIGHT SUBCLAVIAN BETWEEN THE TWO HEADS OF THE STERNO-MASTOID. (*SM*) Sterno-mastoid (the cellular interval between the two heads is opened up and the muscle split upwards). (*IJ*) Internal jugular vein. (*IV*) Right innominate vein. (*A*) Subclavian artery. (*Pn*) Pneumogastric nerve. (*ST*) Sterno-thyroid muscle. (*Cl*) Clavicle.

side and the internal jugular vein towards the outer (see Fig. 83). In dividing this fascia, care must be taken not to puncture the internal jugular vein which is very large and lies immediately underneath it; the division of the fascia and muscle should only be carried out during inspiration, when the vein is not so full. The latter is pulled to the outer side, whilst the sterno-hyoid is retracted towards the middle line, and then the first part of the artery can be seen and cleared, and a double ligature of floss silk or stout catgut passed around it ; the coats should not be divided. The vessel should be tied on the proximal side of the thyroid axis, if possible, and that vessel should also be ligatured.

The Collateral Circulation after Ligature of the First Part of the Subclavian is carried on by the anastomoses of the inferior thyroid arteries

on each side across the middle line, and of this artery with the superior thyroid of the same side; by the superior intercostal communicating with the aortic intercostals; by the branches of the latter vessels communicating with thoracic and scapular branches of the axillary, and by the anastomosis of the superficial cervical with the occipital. If the ligature be placed on the proximal side of the vertebral and internal mammary arteries, the communications of the vertebral with its fellow of the opposite side in the circle of Willis and with the branches of the occipital, and the communications of the intercostal branches of the internal mammary with those of the aorta, and the epigastric branch of the same vessel with the deep epigastric will be important means of carrying on the circulation.

ANEURYSM OF THE AXILLARY ARTERY.

This may be either spontaneous or traumatic; the latter variety is sometimes met with in connection with dislocation of the shoulder joint. It may occur at any part of the vessel; generally it is either in the first or the third part.

TREATMENT.—For axillary aneurysm affecting the first part of the vessel, the best treatment is ligature of the first part of the subclavian. When aneurysm affects the third part of the vessel, the sac enlarges downwards into the loose cellular tissue of the axilla and only rarely extends upwards towards the clavicle, so that the third part of the subclavian can be ligatured without much risk of rupturing the aneurysm.

Ligature of the third part of the subclavian has already been described (see p. 196), but is usually more difficult of performance under these circumstances than when it is performed for aneurysm of the innominate, because the shoulder is pushed up if the axillary aneurysm be large, and there may be great difficulty in exposing the artery; indeed, it may be necessary to divide the clavicle and to pull the two ends aside in order to get at the artery as it crosses the first rib. If this has to be done, the two fragments of the clavicle should be united after the ligature has been applied.

If an aneurysm of the third part of the axillary has resulted from injury, or has become diffuse, it may be advisable to open the sac, turn out the clots, and tie the vessel above and below or to perform endo-aneurysmorrhaphy (see p. 182). An incision should first be made into the lower part of the posterior triangle so as to expose the subclavian artery (see p. 196), and either to enable the assistant to compress it against the first rib with the finger or, better, to allow of a temporary ligature to be passed around it. After the subclavian has been controlled, an incision is made along the line of the axillary artery from the centre of the clavicle to the junction of the upper with the middle third of a vertical line between the two folds of the axilla, when the arm is fully

abducted; if necessary the pectoralis major may be divided so as to obtain better access to the aneurysm. When the sac has been exposed, the artery is identified as it leaves it, and is controlled by pressure, by Crile's clamp (see p. 183), or by a temporary ligature (see Vol. I. p. 107), and then the sac is laid freely open, and the clots turned out. Endo-aneurysmorrhaphy (see p. 182) may then be performed or the artery defined, cleared, and tied above and below the opening. Owing to the close relation of the vessel to the brachial plexus and the axillary vein, it is advisable not to remove the sac. The pectoralis major, if divided, should be sewn together in the manner described for suture of muscles (see p. 63), and the arm is wrapped in wool and lightly fastened to the side.

ANEURYSMS OF THE UPPER EXTREMITY.

Spontaneous aneurysms of the upper extremity below the axilla are very rare. As a rule they result from injuries, usually from puncture of the vessel, and belong to the class of traumatic aneurysms. They may also be caused by septic emboli, detached from the aortic valves in ulcerative endocarditis.

TREATMENT.—Whenever it is possible the treatment consists in opening the sac, turning out the clots, tying the vessel above and below, and excising the sac completely. This can be done without risk, because the entire circulation in the limb can be controlled by an Esmarch's bandage. The actual steps of the procedure depend, of course, upon the particular vessel involved. We shall here describe briefly the operations for ligature of the chief arteries of the upper extremity.

Ligature of the Axillary Artery.—*Surgical Anatomy.*—A line drawn from the middle of the clavicle to the inner margin of the coraco-brachialis, when the arm is abducted to a right angle with the trunk, will indicate the position of the artery. The line of the vessel varies with the position of the limb. If the arm be at right angles to the trunk, the artery is almost straight, and the vein is in front of it. When the arm is elevated above the shoulder, the artery is curved round the head of the humerus, and the vein hides it completely. The size of the vein varies greatly with respiration.

Relations of the First Part of the Artery.—*Behind* are the first digitation of the serratus magnus, the first intercostal space and its muscle, and the posterior or long thoracic nerve. *In front* are the costo-coracoid membrane, the cephalic vein, the platysma, the descending clavicular branches of the cervical plexus, the deep and superficial fascia and the skin. *Above* and to the outer side are the cords of the brachial plexus; *below* and to the inner side are the axillary vein and the internal anterior thoracic nerve.

Relations of the Third Part of the Artery.—*Behind*, the artery rests upon

the subscapularis and the tendons of the latissimus dorsi and teres major. The circumflex and musculo-spiral nerves pass behind this part of the vessel. *In front* are the skin and fascia, the pectoralis major, and the inner head of the median nerve, which crosses it. On the *outer side* are the coraco-brachialis muscle and the median and musculo-cutaneous nerves. On the *inner side* is the axillary vein. The internal cutaneous and ulnar nerves intervene between the artery and the vein, the former

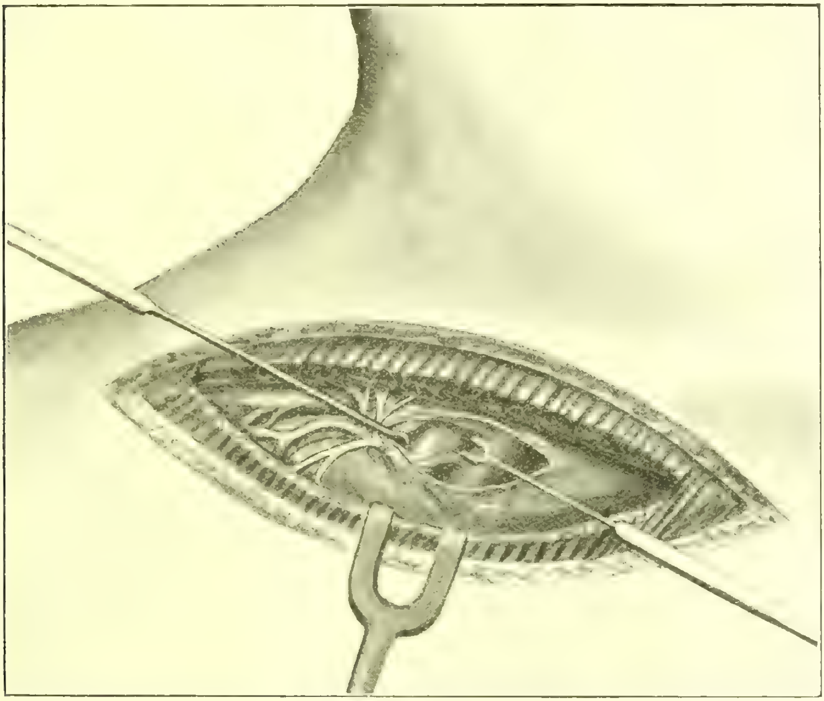


Fig. 84.—Ligature of the First Part of the Right Axillary Artery. The pectoralis major is divided, exposing the costo-coracoid membrane which has been divided in the same direction, exposing the artery and vein. The vein is shown drawn downwards and inwards by the double hook on the right-hand of the figure. To the left of the figure the lowermost cord of the brachial plexus is shown drawn up by a single hook.

being the more superficial. The lesser internal cutaneous lies internal to the vein. The venæ comites of the brachial artery unite to form the axillary vein at the lower border of the subscapularis muscle.

Ligature of the First Part.—This may be necessary either because the vessel has been injured lower down or because there is an aneurysm on the lower part of it. In its first part the vessel may be reached either by a transverse incision below the clavicle, which divides a portion of the clavicular origin of the pectoralis major, or by an oblique incision running downwards in the interval between the pectoralis major and the deltoid.

In the latter situation no muscular fibres are divided. The former method is the one more commonly practised and the easier of performance (see Fig. 84).

The arm is pulled forcibly down, whilst the skin is pulled well up over the clavicle, along which an incision about four inches in length is made down to the bone, running inwards from the level of the coracoid process. The skin is then relaxed and the shoulder pushed up, when the wound in the skin and fascia lies half an inch below the level of the clavicle. This exposes to view the clavicular attachment of the pectoralis major, which is divided in the line of the wound and to the same extent as the skin. The lower portion of the muscle is then pulled well downwards with a retractor, and the costo-coracoid membrane (which is perforated by the cephalic vein, the acromio-thoracic artery and the external anterior thoracic nerve) comes into view. These structures should be pulled to one side, and care must be taken to avoid injury to the cephalic vein and the external anterior thoracic nerve. The costo-coracoid membrane is slit up in the direction of the external wound. The upper edge of the pectoralis minor is defined and pulled downwards, whilst the vessels perforating the costo-coracoid membrane are pulled upwards and outwards. After clearing away some fat, the axillary vein appears as a large distended vessel at the lower part of the wound, whilst above the artery are the cords of the brachial plexus. The lowest of these runs alongside the vein, and should be freed along its lower border and pulled outwards while the vein is pushed inwards. The artery can now be seen between the two, but on a deeper plane, and should be cleared. The needle should be passed from within outwards so as to avoid the vein. The divided pectoralis major should be stitched together in the manner described for wounds of muscles (see p. 63); no drainage tube is required unless the patient be very fat.

Ligature of the Third Part.—Besides being tied for aneurysm of the axillary itself (*vide supra*), the third part of the vessel is sometimes tied for aneurysm of the brachial artery high up in the arm, and is done as follows: The patient lies with the arm abducted to a right angle and the shoulders somewhat raised upon a pillow. An incision is made along the line of the artery, which corresponds to the inner border of the coraco-brachialis muscle, for about three inches. After the deep fascia has been divided, the inner margin of the coraco-brachialis comes into view and is pulled upwards with a retractor. The axillary artery with its vein and the median nerve are at once exposed, and the vessel can be cleared and tied. The median nerve lies on the outer side, the ulnar nerve and the vein on the inner; sometimes there are two venæ comites in place of the large axillary vein (see Fig. 85). The ligature is passed from within outwards, the vein being pulled downwards and the median nerve upwards.

Collateral Circulation after Ligature of the Axillary Artery.—(1) If the first part be ligatured above the origin of the acromio-thoracic, the

collateral circulation will be the same as after ligature of the third part of the subclavian. (2) If the third part be ligatured below the circumflex, the collateral circulation is the same as for ligature of the brachial above the superior profunda. (3) If the ligature be above the subscapular and circumflex branches, the collateral circulation is carried on by the long thoracic and intercostals anastomosing with the thoracic branches of the subscapular; by the suprascapular and acromio-thoracic anastomosing with the posterior circumflex; by the suprascapular and the posterior scapular anastomosing with the scapular branches of the subscapular.

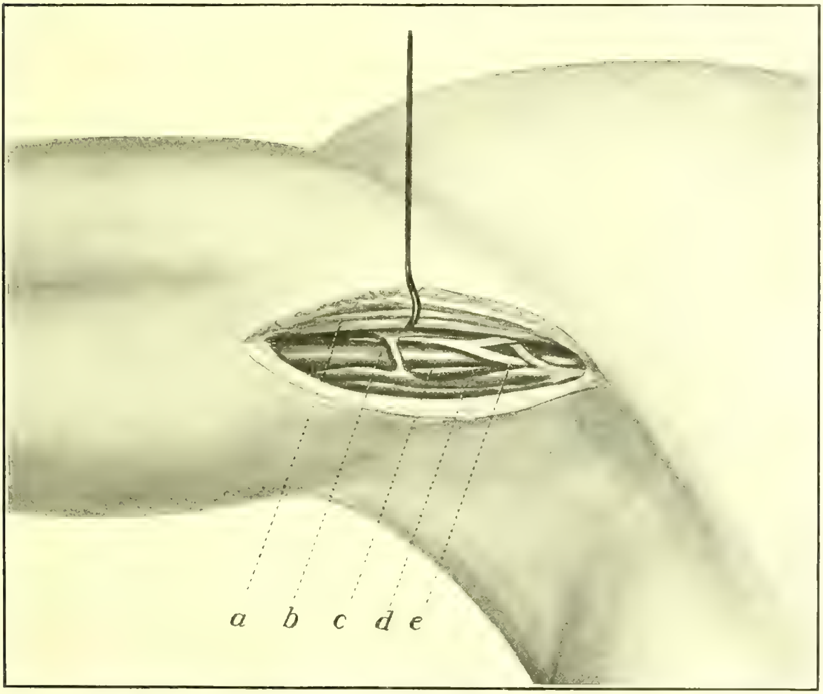


Fig. 85.—Ligature of the Third Part of the Right Axillary Artery. (*a*) Coraco-brachialis muscle; (*b*) axillary artery; (*c*) internal cutaneous nerve; (*d*) venæ comites; (*e*) median nerve.

Ligature of the Brachial Artery.—*Surgical Anatomy.*—The position of the artery is indicated by a line drawn from the junction of the anterior and middle thirds of a line connecting the anterior and posterior axillary folds to the centre of the ante-cubital fossa, when the arm is extended and supinated. *In front*, the artery is overlapped by the inner margin of the biceps and is covered throughout by the skin and deep fascia. The median nerve crosses its centre from without inwards. In the ante-cubital space, the bicipital or semilunar fascia separates it

from the median basilic vein. *Behind,* the artery lies successively upon the long and the internal heads of the triceps, the insertion of the coraco-brachialis, and the brachialis anticus. The musculo-spiral nerve and the superior profunda artery intervene between the artery and the long head of the triceps. On its *outer side* lie the coraco-brachialis muscle, and the median nerve above and the biceps below. On the *inner side* above are the internal cutaneous and ulnar nerves and the basilic vein, and in the lower part is the median nerve. Two venæ comites, one on each side, accompany the artery, and are connected together by branches which pass across the vessel.

Ligature in the Middle of the Arm.—The brachial artery is usually tied

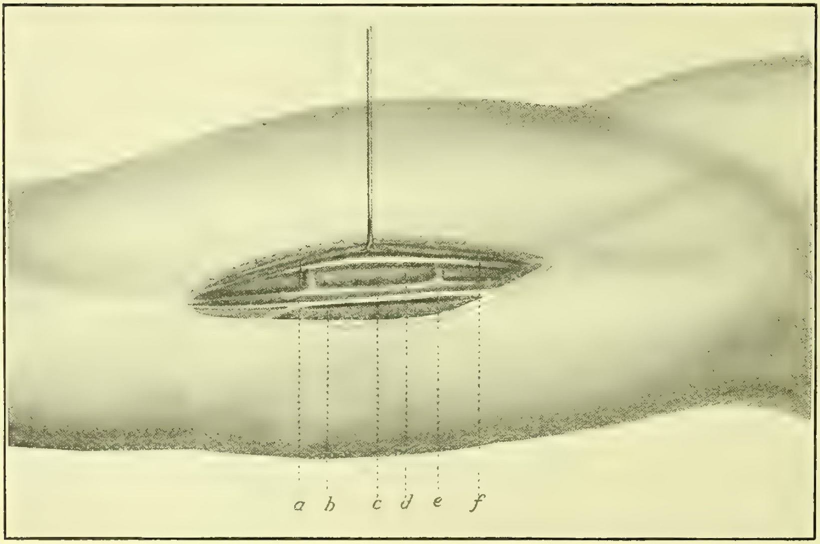


Fig. 86.—Ligature of the Right Brachial Artery in the Middle of the Arm. (*a*) Edge of the biceps drawn upwards ; (*b*) basilic vein ; (*c*) internal cutaneous nerve ; (*d*) brachial artery ; (*e*) venæ comites ; (*f*) median nerve.

in its middle third as it lies over the insertion of the coraco-brachialis muscle. The incision should be about three inches long, parallel to and just below the inner border of the biceps ; the arm should be at right angles to the trunk, and the surgeon should sit between the two. After the skin and fascia have been divided, the edge of the biceps should be freed and pulled upwards, when the artery can be felt immediately beneath the finger. The median nerve will be seen crossing the vessel in front, and when this is drawn upwards, the artery accompanied by a vein on each side will be brought into view (see Fig. 86). It is not uncommon for the brachial artery to divide into its radial and ulnar branches at this point, or even higher up the arm, and one of these has been mistaken for

the main trunk, with a disappointing result. Hence, if the artery appear very small, or, if the bleeding or pulsation do not stop when the vessel is tied, the surgeon should suspect the possibility of the artery having bifurcated higher up, and should look for the other branch of the vessel towards the inner side.

Ligature at the Bend of the Elbow.—The vessel is tied through an incision slightly oblique from above downwards and outwards, parallel to and on the inner side of the biceps tendon, and with its centre opposite the middle of the bend of the elbow. The median basilic vein with the branches of the internal cutaneous nerve will be seen when the skin is divided and should be pulled inwards, when the bicipital fascia comes into view, running downwards and inwards. The upper part of this structure should be divided by a vertical incision, but it is usually not necessary to divide it completely. Immediately beneath will be found the brachial artery, and its venæ comites, somewhat overlapped by the biceps muscle (see Fig. 87).

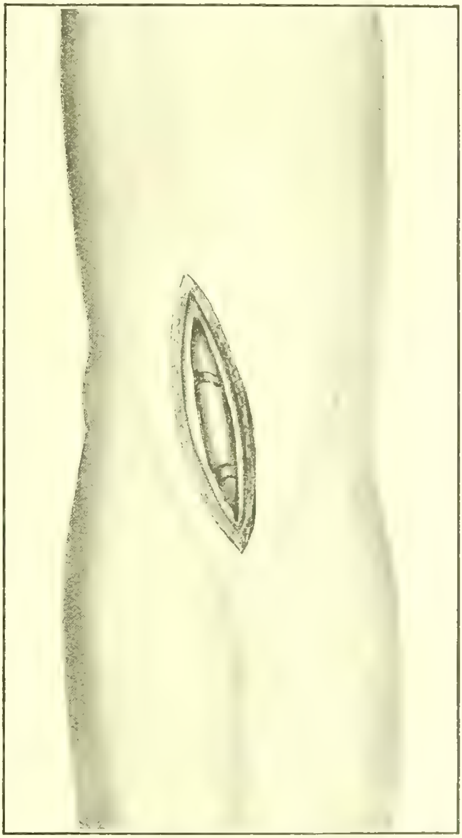


FIG. 87.—LIGATURE OF THE LEFT BRACHIAL ARTERY AT THE BEND OF THE ELBOW. The artery with its venæ comites is exposed through an incision in the bicipital fascia.

Collateral Circulation after Ligature of the Brachial Artery.—(1) *If above the origin of the superior profunda*, by the posterior circumflex anastomosing with the ascending branches of the superior profunda. (2) *If below the origin of the superior profunda*, the superior profunda anastomosing with the anastomotic, the radial recurrent and posterior interosseous recurrent.

Ligature of the Radial Artery.—*Surgical Anatomy.*—The position of the artery in the forearm is represented by a line drawn from the centre of the ante-cubital fossa to the inner side of the base of the styloid process of the radius.

The artery rests in succession on the tendon of the biceps, the supinator

brevis, the pronator radii teres, the radial origin of the flexor sublimis digitorum, the flexor longus pollicis, and the pronator quadratus. On its outer side throughout its whole length is the supinator longus and its tendon. In the middle third, the radial nerve is in contact with the artery. On the inner side, in the upper part, is the pronator radii teres, and in the lower part, the flexor carpi radialis. Superficially the artery is overlapped in the upper part by the supinator longus; in the lower part it is covered by skin and fascia only. There are two venæ comites,

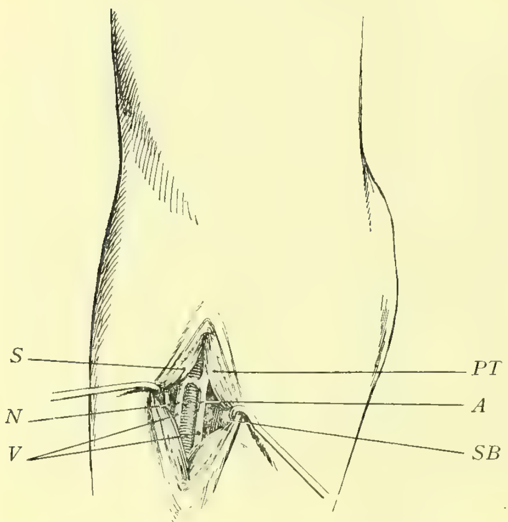


FIG. 88.—LIGATURE OF THE RIGHT RADIAL IN THE UPPER THIRD. (*PT*) Pronator radii teres. (*S*) Supinator longus. (*N*) Radial nerve. (*A*) Radial artery. (*SB*) Supinator brevis. (*V*) Venæ comites.

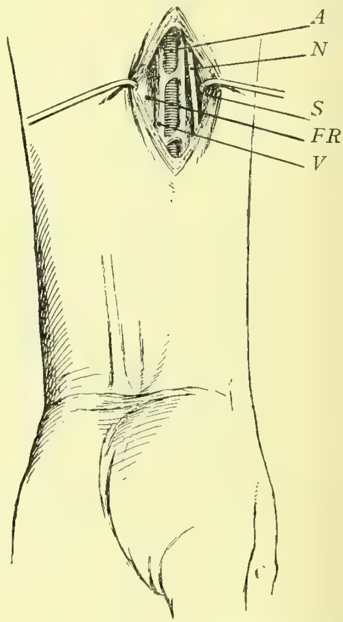


FIG. 89.—LIGATURE OF THE LEFT RADIAL IN THE MIDDLE THIRD. (*S*) Supinator longus. (*FR*) Flexor carpi radialis. (*A*) Radial artery. (*V*) Venæ comites. (*N*) Radial nerve passing beneath the supinator longus.

one on each side of the artery. At the lower border of the pronator quadratus the artery passes to the back of the wrist, lying upon the external lateral ligament, the scaphoid and the trapezium. It is crossed by the extensor tendons of the thumb, and is covered by the skin, some subcutaneous veins and the terminal filaments of the radial nerve. It turns forwards to pass through the first interosseous space into the palm of the hand, where it forms the deep palmer arch.

Ligature in the Upper Third of the Forearm.—An incision is made along the line of the artery, and the interval between the supinator longus and the pronator radii teres is identified. The elbow is then flexed, the

two muscles separated and the supinator longus pulled firmly outwards by a retractor, when the artery will be exposed (see Fig. 88). The radial nerve lies nearly half an inch to the outer side of the vessel and does not come into view.

Ligature in the Middle Third of the Forearm.—The incision should be made along the line of the artery over the interval between the supinator longus and the flexor carpi radialis. The muscles are separated, the former being pulled outwards and the latter inwards, when the vessel will be seen lying upon the radial origin of the flexor longus pollicis and

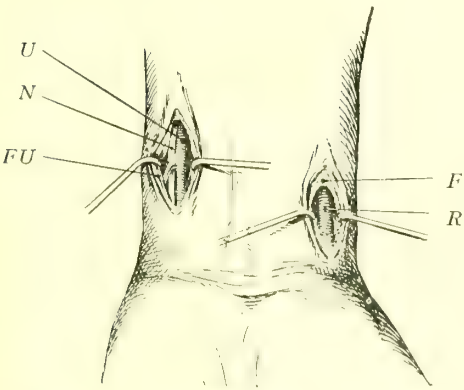


Fig. 90.—Ligature of the Left Radial and Ulnar in the Lower Third. (*FU*) Flexor carpi ulnaris. (*U*) Ulnar artery. (*N*) Ulnar nerve. (*R*) Radial artery. (*F*) Fascia lata.

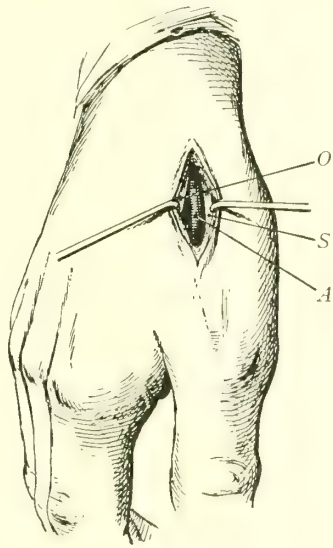


Fig. 91.—Ligature of the Right Radial on the Back of the Wrist. (*O*) Tendon of ext. ossis metacarpi pollicis. (*A*) Radial artery and venæ comites dipping down between bases of first two metacarpal bones. (*S*) Tendon of ext. secundi internodii pollicis.

flexor sublimis digitorum. The radial nerve is close to the outer side of the vessel (see Fig. 89).

Ligature in the Lower Third of the Forearm.—An incision is made along the outer border of the tendon of the flexor carpi radialis, and this will expose the vessel which lies upon the pronator quadratus with a vein on each side of it (see Fig. 90). The radial nerve has left the artery and is on the back of the forearm.

Ligature on the Back of the Wrist.—At the lower border of the pronator quadratus the artery dips down deeply to the back of the hand, and passes beneath the extensor tendons of the thumb. It then turns forward to pass through the first interosseous space into the palm of the hand

The artery may be reached by an incision on the back of the wrist extending from the upper end of the first interosseous space parallel to and somewhat to the radial or outer side of the extensor secundi internodii pollicis tendon. The artery lies deep down on the carpal ligaments, dipping down between the bases of the first and second metacarpal bones beneath the tendinous arch joining the two heads of origin of the first dorsal interosseous muscle (see Fig. 91).

Ligature of the Ulnar Artery.—*Surgical Anatomy.*—The lower two-thirds of this artery may be indicated by a line drawn from the back of the internal condyle of the humerus to the radial side of the pisiform bone. The upper third is indicated by a slightly curved line, with its convexity to the ulnar side of the forearm, extending from the centre of the ante-cubital fossa to the junction of the upper and middle thirds of the first line.

The artery is deeply placed in the upper part of the forearm and has *in front* of it the pronator radii teres, the flexor carpi radialis, the flexor sublimis digitorum, and the palmaris longus muscles. It is crossed by the median nerve, the deep head of the pronator radii teres intervening between the nerve and artery. In the middle third the flexor carpi ulnaris overlaps it; but in the lower third it is covered by the skin and subcutaneous tissue only. *Behind,* it lies successively upon the brachialis anticus, the flexor profundus digitorum, and the anterior annular ligament of the wrist. *On the inner side* is the flexor carpi ulnaris, and in its lower two-thirds the ulnar nerve. On the *outer side* is the flexor sublimis digitorum. The artery is accompanied by two venæ comites, one on each side.

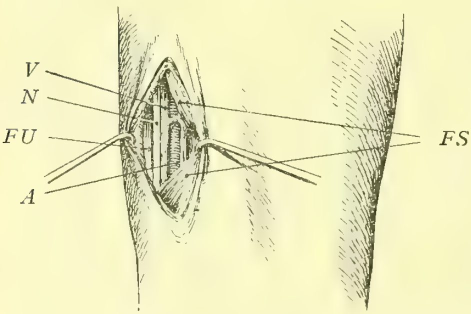


Fig. 92.—Ligature of the Left Ulnar in the Middle Third. (*FS*) Flexor sublimis digitorum. (*FU*) Flexor carpi ulnaris. (*A*) Ulnar artery. (*N*) Ulnar nerve. (*V*) Venæ comites.

Ligature in the Middle Third of the Forearm.—An incision is made in the line of the vessel commencing at the junction of the upper and middle thirds of the forearm, and running downwards for about three inches. After the fascia has been divided, the radial border of the flexor carpi ulnaris muscle is identified, and the intermuscular septum between it and the flexor sublimis digitorum is opened up. The flexor carpi ulnaris is pulled inwards and the flexor sublimis outwards, when the ulnar nerve will be seen lying upon the flexor profundus digitorum to the ulnar side of the artery (see Fig. 92).

Ligature in the Lower Third of the Forearm.—An incision should be

made along the outer or radial border of the tendon of the flexor carpi ulnaris, the deep fascia divided, the tendons of the flexor sublimis digitorum and palmaris longus pulled outwards and that of the flexor carpi ulnaris pulled inwards ; the artery will then be exposed with the ulnar nerve to its inner (or ulnar) side (see Fig. 91).

Collateral Circulation after Ligature of the Radial and Ulnar Arteries.—After ligature of either of these vessels, the collateral circulation is readily established through the palmar and carpal arches, the interosseous branches of the ulnar and the branches of the arteries in the forearm.

ANEURYSM OF THE EXTERNAL ILIAC ARTERY.

Aneurysm of the external iliac generally occurs in the lower part of the vessel and is of the sacculated variety, although it may be fusiform; in the latter case it generally spreads downwards and affects the common femoral trunk. The pressure symptoms are chiefly referred to the anterior crural and genito-crural nerves.

TREATMENT.—The treatment most in vogue at the present time is to apply a *proximal ligature* whenever it can be done. The exact spot at which the ligature is applied will depend upon the situation of the aneurysm. If possible the external iliac trunk should be tied ; but when the aneurysm is situated so high up that there is no room for the application of a ligature between it and the bifurcation, the common iliac may be tied.

Surgical Anatomy of the Common Iliac Artery.—The iliac vessels run along the brim of the pelvis. The right common iliac artery is longer than the left, and has behind it at its origin the commencement of the vena cava, and both the common iliac veins ; lower down, the right common iliac vein is internal to the artery. On the left side the common iliac vein lies internal to and somewhat behind the artery in the greater part of its course. Both arteries are covered by peritoneum, the lower attachment of the mesentery being situated close to the origin of the right vessel, while the left is crossed by the meso-sigmoid. The sigmoid loop lies in front of the left iliac artery, and small intestines in front of the right. The left ureter usually crosses the common iliac artery at or near its bifurcation, but on the right side the ureter in most cases crosses the external iliac.

Surgical Anatomy of the External Iliac Artery.—The external iliac artery is covered throughout its whole length by the peritoneum and the subperitoneal tissue. On the right side, it is crossed by the termination of the ileum, and occasionally the appendix ; on the left side are the sigmoid and some coils of small intestine. In the female the ovarian vessels cross the upper part of the artery ; in the male the spermatic vessels cross it near its termination. Near its lower end also are the genital branch of the genito-crural nerve and the deep circumflex iliac vein ;

it is also crossed here by the vas deferens in the male, and the round ligament in the female. Lymphatic glands lie in front and at the side of the vessel throughout its length. The ureter, descending in the sub-peritoneal tissue, sometimes crosses the artery near its origin. On the right side, the external iliac vein is on the inner side of the artery at its commencement, but inclines behind it as it passes upwards. On the left side, the vein is on the inner side of the artery throughout.

Ligature of the Iliac Arteries.—There are two principal methods

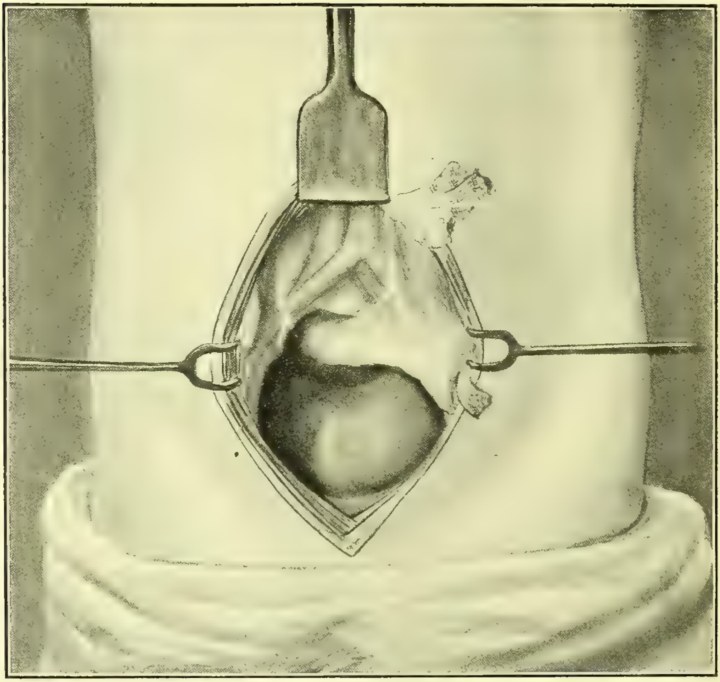


Fig. 93.—Trans-peritoneal Ligature of the Common Iliac Artery. The abdomen has been opened through a median incision, and the small intestines and sigmoid have been packed off with gauze upwards and to the left, thus exposing the vessel.

by which the iliac arteries may be tied, which are termed respectively the trans-peritoneal and the extra-peritoneal methods. The *trans-peritoneal* ligature is performed by opening the abdominal cavity either in the linea semilunaris or in the middle line, and reaching the artery through the posterior layer of the peritoneum after pushing the intestines out of the way. In the *extra-peritoneal* method, on the other hand, the peritoneum is stripped up from the iliac fossa, and the vessel is thus exposed without opening the abdominal cavity. The trans-peritoneal method is the better method in the majority of cases; the extra-peritoneal method is only

really preferable when the ligature is to be applied to the extreme lower end of the vessel. In aneurysm of the external iliac artery there is considerable risk of rupturing the sac when the peritoneum is stripped up from the iliac fossa in the extra-peritoneal operation, and in order to avoid this risk it is necessary to make an extensive incision through the abdominal wall, which may lead to weakness subsequently.

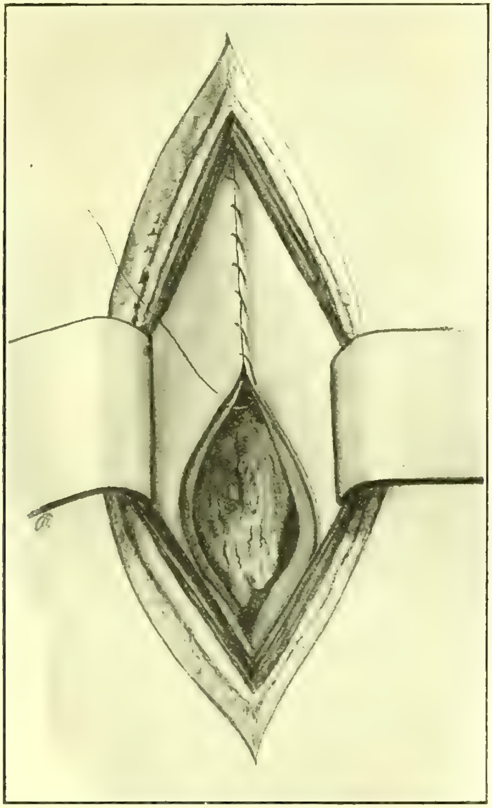


FIG. 94.—SUTURE OF AN ABDOMINAL WOUND IN LAYERS. *First layer.* The peritoneum and the posterior layer of the sheath of the rectus are united by a continuous 'glover's' suture of catgut; at the lower part of the incision the omentum is shown drawn down over the abdominal viscera.

The Trans-peritoneal Operation.—To reach the vessel by the trans-peritoneal method an incision should be made either in the middle line or through the linea semilunaris on the affected side. Unless the patient be very fat it is always better to make the incision in the middle line, as it is easy to pull the margins of the incision to one side, so as to bring it over the brim of the pelvis. The patient is put in the Trendelenburg position, and a vertical incision four to five inches long is carried

downwards from just below the umbilicus. The skin, superficial fascia, and the front layer of the sheath of the rectus are divided, and the posterior layer of its sheath is opened. The peritoneum is then slit up throughout the whole extent of the wound (see Fig. 93).

In stout subjects, and in cases in which the external iliac artery is

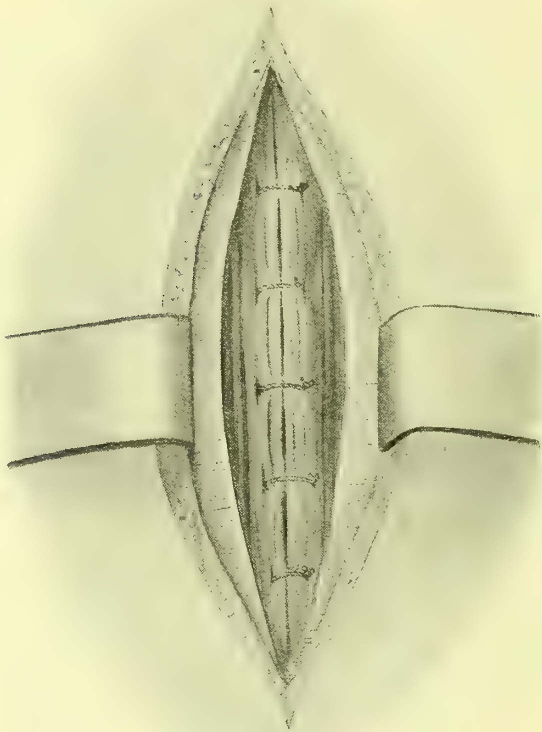


FIG. 95.—SUTURE OF AN ABDOMINAL WOUND IN LAYERS. *Second layer.* The abdominal muscles have been drawn together by a series of interrupted sutures inserted at right angles to the direction of the muscular fibres.

to be tied moderately low down, it is better to make the incision just inside the linea semilunaris. The objection to this is, however, that the nerves supplying the rectus muscle are necessarily divided. The incision is about four inches long and commences about half an inch below the level of the umbilicus. The skin, superficial fascia, and anterior part of the sheath of the rectus are divided, and the rectus is either pulled inwards, or, if very well developed, its fibres may be split a little to the inner side

of the linea semilunaris. The posterior sheath of the rectus and the peritoneum are then divided. By making the incision a little to the inner side, opening the sheath of the rectus, and either splitting its fibres or pushing them inwards, the chance of hernia after the operation is

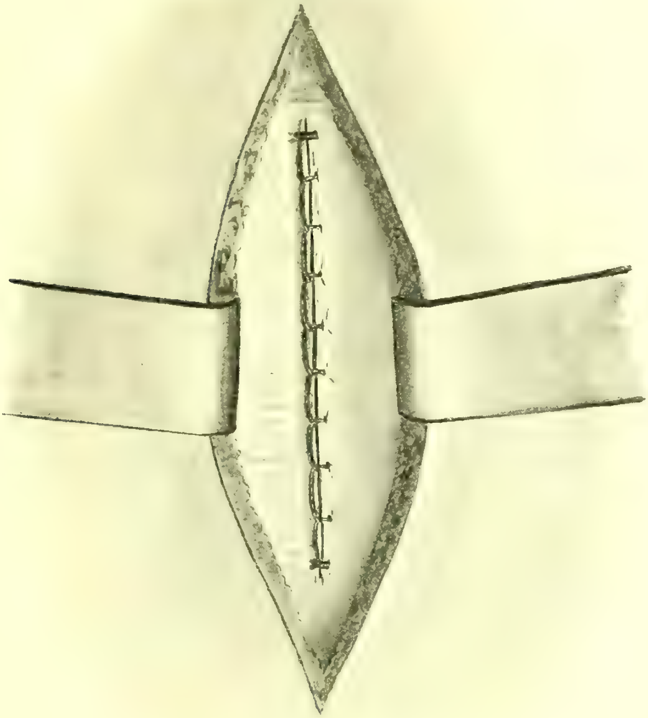


FIG. 96.—SUTURE OF AN ABDOMINAL WOUND IN LAYERS. *Third layer.* The anterior layer of the sheath of the rectus is closed by a continuous suture of fine silk.

less than when the incision is carried accurately through the linea semilunaris. This incision gives good access to the external iliac vessel; should it be necessary to tie the common trunk, satisfactory access to it can be gained by prolonging the upper end of the incision in the abdominal wall somewhat inwards towards the middle line.

After the abdomen has been opened by either of these incisions the

intestines are carefully packed away in the upper part of the abdomen with abdominal cloths. On the right side the cæcum and the adjacent part of the ileum are displaced upwards, and on the left the sigmoid flexure. The direction and extent to which this latter structure can be displaced will depend upon the position of the meso-sigmoid in relation to the external iliac artery ; usually it can be displaced upwards. The limits of the aneurysm are next defined with the finger, and the pulsation of the artery is felt for above the point where the dilatation commences. It is also important that the position at which the ureter crosses the vessel should be made out. An incision is then made in the peritoneum over the vessel; the latter is carefully cleared, and the ligature passed from within outwards.

Fig. 97.—Astley Cooper's Incision for Extra-peritoneal Ligature of the Common or External Iliac Artery. The outlines of the pelvis and the pelvic brim are shown. The thick line denotes the incision.

On the right side the artery is readily accessible, and the peritoneum may be incised directly over it without fear of bleeding ; on the left side there may be many large arterial branches running in the meso-sigmoid, and in that case it is better to incise the peritoneum near the middle line, and to raise it outwards over the vein until the artery is reached. In the iliac vessels, as in the innominate, it is well to employ the double ligature recommended by Ballance and Edmunds (see p. 177), so as to avoid complete division of the coats. When clearing the vessel on the right side care must be taken to avoid puncturing the vein.

After the vessel has been tied, the opening in the peritoneum over it should be closed by a catgut stitch, and the abdominal incision sutured in the usual manner, the peritoneum being first stitched up with a fine continuous catgut suture, the muscles on either side brought together by silk 'mattress' sutures (see Figs. 94–96), and the skin united with a continuous silk suture.

The Extra-peritoneal Operations.—The extra-peritoneal ligature of the external or common iliac artery is not a good method for cases in which the aneurysm is situated upon those vessels. It may, however, be employed with advantage when the aneurysm is situated high up on the superficial femoral. There are two methods of performing this operation, which are known respectively as Abernethy's and Astley Cooper's. The former was employed chiefly when the upper end of the external iliac or the common trunk was to be tied, but for these arteries the trans-peritoneal operation is preferable.

Astley Cooper's Operation.—Astley Cooper's operation is performed

through an incision which extends from a point $1\frac{1}{4}$ inches external to the spine of the pubes, and half an inch above Poupart's ligament to another on a level with, and an inch internal to, the anterior superior iliac spine. The first half of this incision is parallel to Poupart's ligament (see Fig. 97). By this method the artery is freely exposed below, and, should the case be one in which the ligature can be applied to the lower part of the

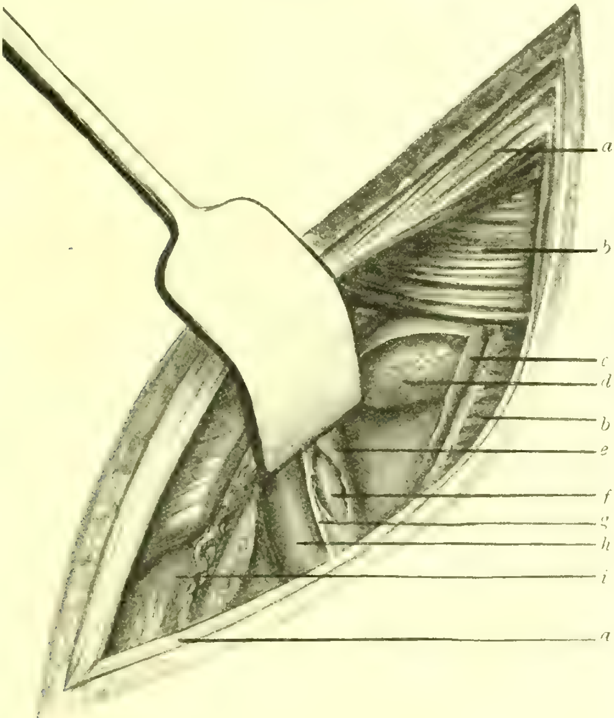


FIG. 98.—LIGATURE OF THE LEFT EXTERNAL ILIAC ARTERY BY ASTLEY COOPER'S METHOD. (*a*) External oblique muscle; (*b*) internal oblique partially divided; (*c*) fascia transversalis; (*d*) peritoneum covered with retro-peritoneal fat; (*e*) external iliac artery in its sheath; (*f*) the artery exposed through an incision in the sheath; (*g*) genito-crural nerve; (*h*) external iliac vein; (*i*) spermatic cord.

external iliac trunk, this incision should be used, because it causes the least weakening of the abdominal wall and the smallest amount of disturbance of the soft parts. When, however, the artery requires to be ligatured high up, or when there is a possibility of the common or the internal iliac requiring ligature, the trans-peritoneal operation is the better.

The muscles beneath the outer part of the incision are retracted or divided if necessary, and any bleeding points are secured as they are cut. The transversalis fascia is exposed and divided to the full extent of the

external wound. This exposes the sub-peritoneal fat and fascia which lies immediately outside the peritoneum. Care must be taken to identify these structures, as it is common to mistake the transversalis fascia for the peritoneum in ligaturing these vessels, and to strip it up from the iliac fossa, carrying with it the vessels, so that they are in front of the finger ; the surgeon then cannot find the vessels. After the transversalis fascia has been divided, the patient is rolled over towards the sound side, and the peritoneum is gently separated from the posas and iliacus muscles until the vessels are exposed (see Fig. 98). The wound is then retracted with broad copper spatulæ, the sheath of the artery opened in front by a small incision, and the aneurysm needle gradually insinuated around it from within outwards.

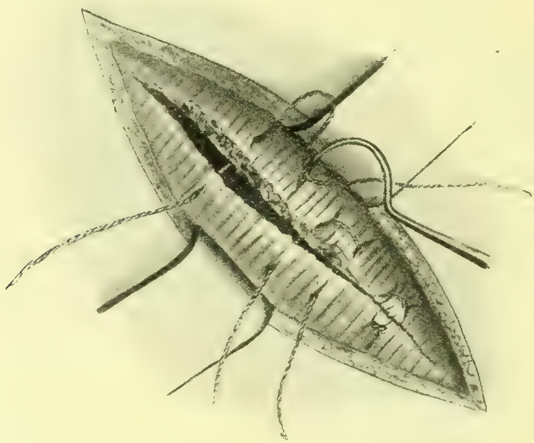


FIG. 99.—SUTURE OF MUSCLES BY THE MATTRESS STITCH.—This suture is used when the muscular fibres have been divided transversely.

In Astley Cooper's operation the cord and the vas are displaced upwards and inwards along with the transversalis fascia, and the only structure requiring special attention is the genito-crural nerve, which lies on the sheath of the artery and must not be included in the ligature. After the vessel has been ligatured, the peritoneum is replaced, the muscles are united in layers by silk (see Fig. 99), and the skin is brought together by a continuous suture. No drainage tube is required.

After-treatment.—After the operation the whole lower extremity should be carefully disinfected (see Vol. I. p. 100), wrapped in a large mass of salicylic wool and somewhat elevated upon a pillow ; sandbags are applied along the side of the trunk to keep the patient still, while great care is taken to see that there is no constriction anywhere in the limb and no undue pressure, especially about the heel. The object is to

obviate or delay the occurrence of sepsis, should gangrene result from ligature of the main vessel. The time at which the patient may be allowed to move about and sit up is discussed in connection with femoral aneurysm (see p. 237).

Collateral Circulation after Ligature of the Common Iliac Artery.—This is maintained by the internal mammary and the lower intercostals anastomosing with the deep epigastric ; by the deep circumflex iliac and ilia-lumbar anastomosing with the lumbar arteries ; the middle sacral with the lateral sacral ; the superior hæmorrhoidal with the inferior and middle hæmorrhoidal ; the branches of the pudic, epigastric, obturator and vesical arteries, with those of the opposite side.

Collateral Circulation after Ligature of the External Iliac.—This is carried on by the deep and superficial epigastrics anastomosing with the superior epigastric of the internal mammary and with the lumbar and lower intercostal arteries ; by the deep and superficial circumflex iliacs with the lumbar and gluteal arteries ; by the obturator with the internal circumflex ; by the sciatic with the internal and external circumflex, and the first perforating branch of the profunda ; by the gluteal with the ascending branch of the external circumflex ; and by the terminal branches of the internal pudic with the superficial and deep external pudic.

FEMORAL ANEURYSM.

This may be situated upon the common or the superficial femoral artery, but as a rule an aneurysm of the superficial femoral artery is implied when the term ' femoral aneurysm ' is used, the term generally applied to aneurysm of the external iliac trunk or the adjacent part of the common femoral artery being ' inguinal aneurysm.' Aneurysm of the profunda branch of the femoral artery is extremely rare.

Aneurysm of the superficial femoral may occur either in Scarpa's triangle or in Hunter's canal ; it is, perhaps, more frequent in the former situation. In either case, it may cause serious pressure symptoms and may produce marked œdema of the limb from pressure on the femoral vein. It also gives rise to considerable pain, chiefly referred to the inner side of the thigh and upper part of the leg, which is due to pressure upon the long saphenous nerve. Aneurysms of the femoral artery either in Scarpa's triangle or in Hunter's canal not infrequently become diffuse, and it will therefore be necessary to consider the treatment of aneurysm in this situation according as the affection is circumscribed or diffuse.

CIRCUMSCRIBED FEMORAL ANEURYSM.

TREATMENT.—Here there is a choice between compression, ligature, and aneurysmorrhaphy.

Compression of the Femoral Artery.—We are of opinion that treatment by compression should only be employed when the patient

refuses operation, or when he is suffering from some grave constitutional affection, such as cardiac disease or diabetes. The vessel compressed is generally the common femoral at the groin.

Digital compression should always be chosen in preference to the use of instruments, because the compression can be kept up more satisfactorily and with less pain to the patient. The great disadvantage of it is that a number of assistants are required; it is impossible for any individual to keep up satisfactory pressure for much longer than fifteen minutes at a time, and in some cases many hours may be required before a cure is effected.

The patient should be confined to bed for some days before the compression is practised, the bowels cleared out, and a preliminary course of medical treatment employed, in order to lower the blood pressure and promote the coagulability of the blood (see p. 172). Several days before the compression, the groin should be shaved, and sponged over with spirits of wine several times a day so as to increase its resisting power. The shaving minimises the danger of pustular eruptions from the friction of the compression, which might interfere with its proper performance. The skin should also be disinfected, so as to remove organisms which might be rubbed into the hair follicles. Immediately before the compression, the skin should be thickly dusted with equal parts of oxide of zinc and boric acid, and a large piece of boric lint should be applied over the part of the vessel to which the pressure is to be applied.

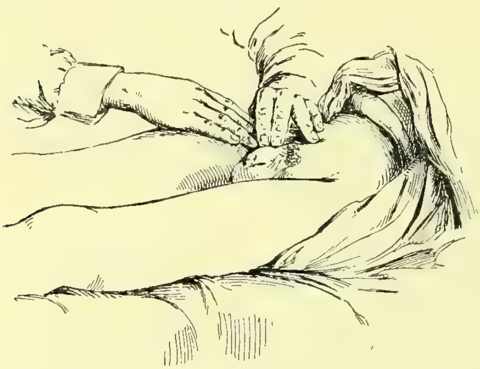


Fig. 100.—Digital Compression of the Common Femoral Artery. The pressure of the fingers may be reinforced by a leaden weight or a bag of shot. The method illustrated is better than compression by encircling the limb with the two hands and making pressure with the thumbs, as less muscular effort is required.

In employing compression the assistant first feels for the pulsation of the artery as it passes over the brim of the pelvis at a point midway between the anterior superior iliac spine and the symphysis pubis, and when this is found he exerts pressure directly backwards. When the superficial femoral is compressed in Scarpa's triangle, the pressure should be directed backwards and outwards against the shaft of the femur. The simplest way to employ compression is for an assistant to sit in a chair upon the affected side and to place two or three fingers of the right hand directly over the line of the artery, and make pressure with them against the brim of the pelvis until pulsation in the aneurysm ceases. The pressure may be reinforced by two or three fingers of the left hand applied over

those of the right (see Fig. 100). Upon the fingers may be laid a bag containing two or three pounds of shot, or a leaden weight of suitable size and shape, so as to diminish the amount of muscular effort required ; with this aid it may be possible to maintain compression for a longer period than fifteen minutes. When the assistant becomes tired, a second should apply pressure higher up or lower down over the vessel, and should control the circulation before the first assistant relaxes his pressure. Pressure may thus be kept up by a relay of men either until coagulation in the aneurysm is complete or until the patient can tolerate the pressure no longer.

It is difficult to say exactly how long pressure should be kept up, as so much depends upon the individual patient. Cases are known in which a cure has resulted after the application of pressure for as short a time as four hours, whilst in others the duration of the treatment has been measured by days. Speaking generally, perhaps, we might say that pressure should be maintained for from four to eight hours in the first instance, and then the patient may be left alone for a day or two, so as to give the skin and soft tissues time to recover from the pressure to which they have been subjected. It not infrequently happens, under these circumstances, that, although pulsation returns in the vessels when the pressure is first relaxed, coagulation still continues in the sac, and the aneurysm may be cured without any second compression being required. Should this not happen, however, and should the patient be able to bear it, the compression may be resumed the following day for four or five hours. It is well to keep the patient fully under the influence of morphine by repeated hypodermic injections, so as to diminish the pain which accompanies the treatment and which is often very severe ; this must not be done, however, when there is renal disease. If, in spite of morphine, the pain becomes intolerable, ligature had better be employed. It has been suggested that chloroform should be administered in place of morphine, but, if this is to be done, the chief objection to operation is done away with, and it is then much better to tie the artery.

Ligature of the Femoral Artery.—In the large majority of cases, the surgeon will resort to ligature of the femoral artery in preference to compression, and whenever it is feasible the superficial femoral should be the vessel tied. Should the aneurysm happen to affect the upper part of the superficial femoral or the profunda femoris, however, it will be necessary to ligature the common femoral artery.

Surgical Anatomy.—The position of this vessel may be indicated by a line drawn from the mid-point between the anterior superior iliac spine and the symphysis pubis, to the adductor tubercle of the femur, when the limb is abducted and externally rotated, the knee being flexed.

The first inch and a half or two inches of the artery is usually designated the common femoral, the rest (below the origin of the profunda femoris) being called the superficial femoral. At its commencement

the artery is contained in the outer of the three compartments of the femoral sheath.

In Scarpa's triangle, the artery is *covered* by skin and superficial fascia, the superficial inguinal glands, and superficial vessels. The anterior layer of the femoral sheath and the cribriform fascia are in front

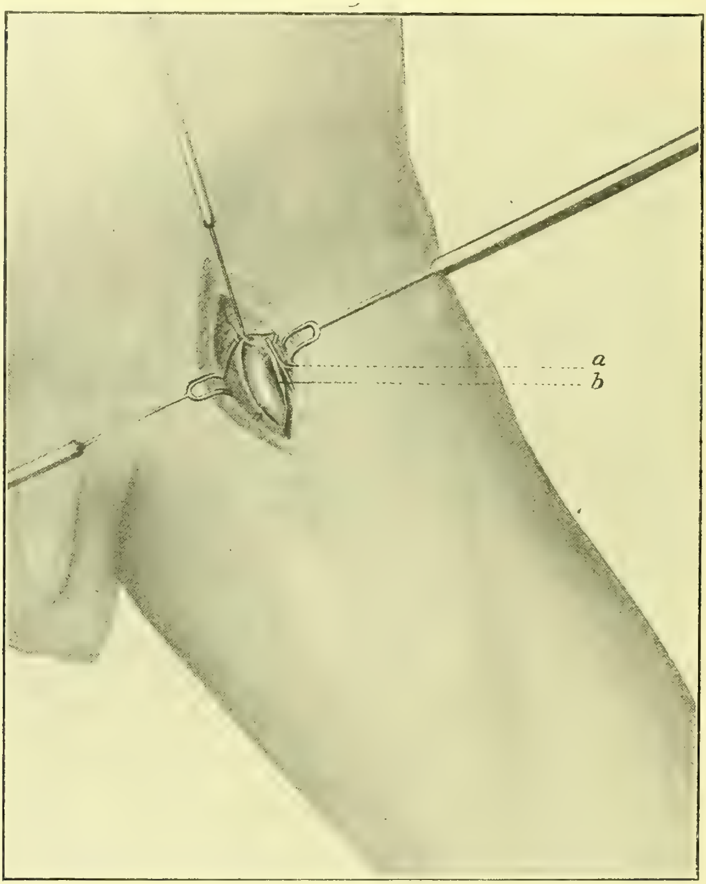


FIG. 101.—LIGATURE OF THE LEFT COMMON FEMORAL BELOW POUPART'S LIGAMENT. (*a*) Artery; (*b*) crural branch of the genito-cruarl nerve.

of the upper part of the vessel, and the fascia lata in front of the lower part of it. The internal cutaneous nerve crosses the artery near the apex of the triangle. *Behind,* the artery rests in succession on the posterior layer of the femoral sheath, the pubic portion of the fascia lata, the psoas and the pectineus muscles. The nerve to the pectineus passes between the psoas and the artery ; the femoral vein and the profunda artery and vein lie between it and the pectineus.

On the *outer* side of the artery above is the anterior crural nerve, and lower down the long saphenous nerve. The crural branch of the genito-crural nerve is in front of, and to the outer side of the artery above, and for a short distance is within the femoral sheath.

In *Hunter's canal*, the artery is covered by the aponeurotic covering of the canal, the sartorius, the skin and the deep and superficial fasciæ. *Behind* are the adductor longus and magnus, and to the *outer* side is the vastus internus muscle. The long saphenous nerve is at first to the outer side; then it crosses the front of the artery, and finally lies on its inner side. The nerve to the vastus internus is on the outer side of the artery. The vein is posterior, and, to some extent, external to the artery.

Ligature of the Common Femoral Artery.—The thigh is somewhat abducted and rotated outwards, with the knee in the semi-flexed position supported by a sandbag. An incision two or three inches long, with its centre about half an inch below Poupart's ligament is made along the line of the artery (see Fig. 101). This incision divides the skin and superficial fascia, in which enlarged lymphatic glands are often met with; they should be pulled aside, or removed if large. A few superficial veins may also require ligature. The deep fascia is incised, the pulsation of the artery felt for, a small incision made in the sheath of the vessel, and an aneurysm needle inserted around it. The ligature should be passed from the inner side, so as to avoid the vein; a single ligature suffices for tying the femoral artery and any of the vessels lower down in the limb, and there is no objection to division of the internal and middle coats. Care must be taken not to include in the ligature the crural branch of the genito-crural nerve, which descends upon the front of the artery, otherwise severe pain may result. The wound is closed without a drainage tube and the limb is disinfected, wrapped in salicylic wool, and slightly elevated.

Ligature of the Superficial Femoral.—The seat of election for ligature of this vessel is the apex of Scarpa's triangle, but when the aneurysm occupies that situation it may be necessary to tie the vessel in the middle or even the upper part of the triangle. The line of the vessel is the same as that of the common femoral (see p. 233).

In ligaturing it *at the apex of Scarpa's triangle*, an incision is made in the line of the vessel with its centre about the apex of the triangle (*i.e.* about a hand's breadth below Poupart's ligament), dividing skin, superficial and deep fascia. The inner border of the sartorius then comes into view, but care must be taken not to mistake the adductor longus for this muscle, as it may be exposed should the incision be made rather too far inwards. The identification should be easy, as the fibres of the sartorius run downwards and inwards, whilst those of the adductor longus run directly downwards, or downwards and slightly outwards. The sartorius should be drawn outwards with a retractor. Should the adductor longus be at all prominent it may be drawn to the inner side (see Fig. 102). The fascia over the femoral artery is divided, the sheath opened, the vessel

cleared, and the artery ligatured, the needle being passed from the inner side. No drainage tube is required, and the limb is treated in a similar manner to that after ligature of the common trunk. The artery usually lies somewhat in front of the vein, with the long saphenous nerve on its outer side.

Collateral Circulation after Ligature of the Femoral Artery.—(1) *After ligature of the common femoral* the circulation is maintained by the anastomosis of the internal with the external pudic; the gluteal and the sciatic with the ascending branch of the external circumflex, the internal

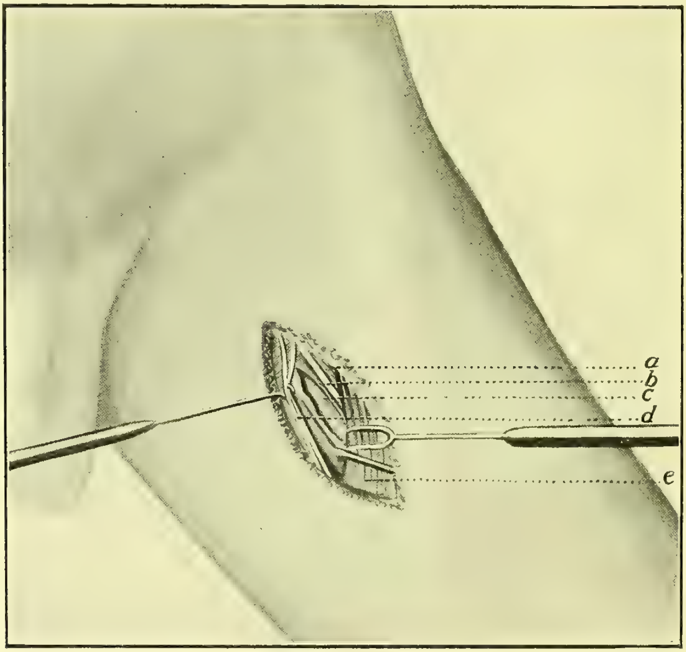


FIG. 102.—LIGATURE OF THE LEFT SUPERFICIAL FEMORAL AT THE APEX OF SCARPA'S TRIANGLE. (*a*) Anterior crural nerve; (*b*) long saphenous nerve; (*c*) femoral artery; (*d*) cutaneous nerves; (*e*) sartorius.

circumflex and the superior perforating; the obturator with the internal circumflex; the circumflex iliac with the external circumflex; and the comes nervi ischiadici with the perforating branches of the profunda. (2) *After ligature of the superficial femoral,* the circulation is carried on by the external circumflex anastomosing with the anastomotica magna, the lower muscular branches of the femoral, and the superior articular branches of the popliteal; the perforating branches, and the termination of the profunda with the muscular branches of the femoral and popliteal, and the superior articular branches of the latter vessel.

After-effects.—The first subjective result of ligature of either of these

vessels is a feeling of coldness, with pain and cramp in the lower extremity. These sensations usually pass off during the first twenty-four hours, and are due to deficiency in the circulation of the limb ; sometimes also there is pain about the seat of the aneurysm as a result of its distension by clot when coagulation takes place. Should this pain be excessive, there is no objection to the administration of full doses of morphine unless there are other features in the case which contra-indicate the use of the drug. After the lapse of twenty-four hours the toes should be examined ; as a rule they will be warm and of good colour by that time. The simplest way to ascertain whether the circulation is maintained is to press upon the point of the nail and force the blood out of the matrix. On relieving the pressure the blood ought to flow back again immediately, and, should it be slow in doing so, it is a sign that the circulation is much impaired. Should impairment of the collateral circulation last for forty-eight hours, it is highly probable that gangrene will occur. As the surgeon knows what vessels are blocked, he need not wait for a line of demarcation before amputating. At the same time he may wait a short time in case the gangrene should be quite limited. When the gangrene is extensive, amputation must be performed within the area of distribution of the branches of the profunda femoris and their anastomoses, that is to say, at the knee-joint.

When gangrene does not take place, the consolidation and shrinking of the aneurysm go on rapidly. Consolidation is usually accompanied by pain radiating from the seat of the aneurysm down the leg, which may continue until the aneurysm has completely disappeared. The patient should be kept in bed for about six weeks after the operation, so as to allow a certain amount of consolidation of the clot to take place, and it is well to restrict the movements of the knee afterwards until such time as the aneurysm has almost disappeared. With this object the patient should go about upon crutches, and the knee should be fitted with a suitable casing which may be prolonged upwards so as to protect the aneurysm from injury. Fixation of the knee-joint is more especially important in cases of popliteal aneurysm.

Complications.—Should the surgeon happen to *puncture the vein* during the operation, the best plan is to apply two ligatures to the artery, and divide it between them ; in this way the puncture in the vein is easily exposed. It is impossible to employ pressure to stop the bleeding from the vein, as would be done under ordinary circumstances, on account of the risk of gangrene from interference with the collateral circulation. The surgeon has choice of two methods in which he will be influenced by the size of the aperture in the vein ; should it be quite small, a lateral ligature will suffice to close it : should the wound be too large for this, the vein may be stitched up in the manner described for the treatment of wounds of veins (see p. 146). The entire lumen of the vessel should never be occluded if it be possible to avoid it, as such a procedure would offer

increased resistance to the return of blood, and this might just turn the scale in favour of gangrene when the tissues are feeble. In vigorous, healthy individuals, however, complete transverse ligature of the vein does not seem materially to complicate matters.

The Old Operation.—The old operation in this situation is performed as follows : The limb is placed in the position for ligature of the femoral artery, and the circulation is controlled by the fingers of an assistant who compresses the common femoral as it passes over the brim of the pelvis, or by a temporary ligature (see Vol. I. p. 107) around the vessel. The surgeon then makes an incision, according to the size of the aneurysm, along the course of the superficial femoral artery, and if there be sufficient room between the aneurysm and the assistant's finger it is well to tie the femoral artery above the latter before opening the sac. The assistant then relaxes the pressure, the aneurysmal sac is laid freely open, all the clots are turned out, and the bleeding from the lower end is arrested, at first temporarily by digital pressure, and subsequently by clearing the vessel and applying a ligature on the distal side of the opening. When all the clots have been turned out, it is well to isolate and clip away as much of the sac as possible. The posterior part of it is best left behind, however, as the dissection needed to separate it from the vein might easily injure the latter.

When it is impossible to secure the artery on the proximal side of the aneurysm before opening the sac, a small incision must be made into the sac and plugged at once by introducing the finger into it. The finger feels for the opening of the vessel, occludes it by pressure, and the artery on the proximal side is rapidly cleared and a ligature applied to it. The finger is then withdrawn, the sac laid freely open, and the operation is finished as above described.

If the circulation on the proximal side of the aneurysm can be controlled, Matas's operation of endo-aneurysmorrhaphy may be performed (see p. 182).

RUPTURED (DIFFUSE) FEMORAL ANEURYSM.

TREATMENT.—Should the sac of the aneurysm have ruptured, the best treatment will be to control the vessel on the proximal side of the aneurysm, and then cut down upon the tumour, and turn out the clot from the sac and the tissues around. After this has been done, the surgeon has the choice of doing Matas's operation (see p. 182), or ligaturing both ends of the vessel, and, if possible, excising the sac wall. Matas's operation is probably preferable if it can be done, as it may enable the direct circulation through the femoral to be maintained, or may give the collateral circulation time to become efficient. In former times rupture of a femoral aneurysm was regarded as an accident which necessitated amputation, partly on account of the great risk of gangrene if the artery were ligatured,

owing to the collateral circulation being interfered with by the clots infiltrating the tissues around, and partly on account of the risk of suppuration in the limb which resulted from septic infection of the clot. At the present time this latter risk is avoided by adequate antiseptic precautions, and the clots may therefore be safely turned out; the pressure upon the collateral circulation is thereby relieved, and the risk of gangrene from this cause avoided. Hence amputation should not be performed in these cases unless it is evident that gangrene has set in.

It will often be found that, in spite of ligature of the main artery above and below the aneurysm, oozing still takes place into the sac; this generally comes from small branches given off from the aneurysm. These must be isolated and occluded, as otherwise considerable bleeding into the cavity may occur, and serious pressure upon the collateral circulation, caused by the extravasation of blood, may result. A drainage tube or tubes are inserted, and the limb is elevated and watched carefully for signs of gangrene (see p. 237). It is necessary to employ a drainage tube in these cases, because of the oozing that must necessarily occur into the large cavity left. This cavity cannot be obliterated by sponge pressure in the ordinary way, as that would entail a serious risk of gangrene from interference with the collateral circulation.

POPLITEAL ANEURYSM.

The popliteal artery is one of the most common seats of aneurysm, which is most prone to occur in men whose occupations lead to frequent, rapid, and violent flexion of the knee. In former times it was common in conductors of coaches, and it is also not infrequent in soldiers and sailors. The aneurysm gives rise to difficulty in using the knee, and pain along the course of the nerves, especially the internal popliteal; it is particularly liable to become ruptured and diffuse from the forcible flexions of the knee. The posterior ligaments of the knee-joint may be eroded and the aneurysm may burst into the articulation, or it may become diffused into the popliteal space itself, or may make its way through the skin over it.

TREATMENT.—The procedures employed for the treatment of popliteal aneurysm may be either compression or operation. We have already discussed the relative merits of these two plans, and have described in detail the method of carrying out *compression*, which should be applied to the upper part of the femoral artery (see pp. 231–3). Amongst operative procedures for the cure of popliteal aneurysm, the surgeon has the choice between the old operation of incising the sac and tying the vessel above and below, ligature of the popliteal artery at its commencement, ligature of the femoral artery in Hunter's canal or Scarpa's triangle, excision of the sac, which should only be done when the aneurysm is small and situated in the upper part of the artery, or

Matas's operation, which was first designed for the treatment of these aneurysms. This operation is described on p. 182.

Ligature of the Superficial Femoral Artery.—In the ordinary cases of popliteal aneurysm proximal ligature is perhaps the safest plan, as it does not involve any risk of injury to the nerves or the vein.

At the Apex of Scarpa's Triangle.—When proximal ligature is determined upon, the point at which the artery is tied will depend to some extent upon the situation of the aneurysm. It is generally done at the

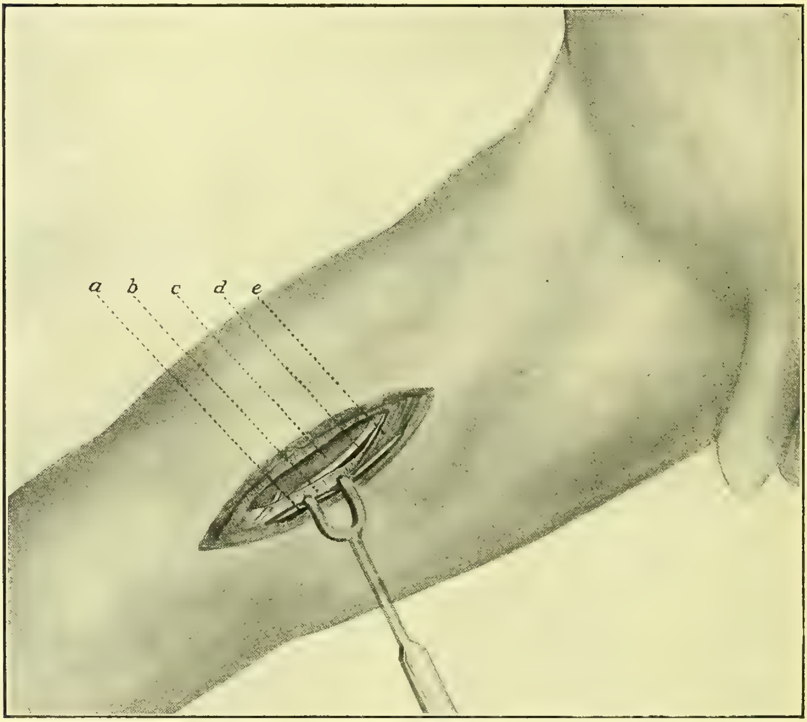


FIG. 103.—LIGATURE OF THE RIGHT SUPERFICIAL FEMORAL IN HUNTER'S CANAL. (*a*) Long saphenous vein; (*b*) fascia covering Hunter's canal; (*c*) femoral artery; (*d*) long saphenous nerve; (*e*) sartorius.

apex of Scarpa's triangle (see p. 235). John Hunter, in introducing his operation, tied the artery in what is known as Hunter's canal; while some surgeons, with whom we are inclined to agree, tie the vessel, whenever it is possible, at the upper part of the popliteal space.

In Hunter's Canal.—Ligature of the artery in Hunter's canal is performed as follows: The knee is somewhat flexed, the thigh rotated outwards, and the surgeon standing on the inner side of the limb makes an incision from three to four inches long in the line of the artery over the middle third of the thigh. After the skin and fascia have been divided, the

sartorius will be exposed as it crosses the space obliquely from without inwards (see Fig. 103). It is usually most convenient to draw this muscle to the inner side, but should the surgeon be operating at the upper part of the canal he will find it more easy to pull it outwards. This exposes the fibrous connection between the adductor longus and the vastus internus which forms the roof of Hunter's canal. A portion of this should be picked up in dissecting forceps and nicked, and the canal then laid open throughout the whole length of the incision upon a director or by means of the finger guiding a probe-pointed bistoury. This will expose the artery, which runs along the floor of the space with the saphenous nerve on its outer side and the femoral vein behind it. At the lower part of the canal the latter passes somewhat to the outer side of the artery. In this situation the saphenous nerve crosses the front of the vessel from the outer to the inner side, close to the spot at which the artery passes through the opening in the adductor magnus. Here also the anastomotica magna comes off and runs downward towards the knee. The artery in Hunter's canal is always tied above the origin of this branch. To do this the sheath of the artery is opened, the vessel cleansed, and the needle passed from the outer side just above the origin of the anastomotic branch. The after-treatment is that already described for the other ligatures of this vessel.

Ligature of the Popliteal Artery.—As the anastomotica magna is one of the main factors in carrying on the collateral circulation, it is a better plan to tie the artery below the origin of that vessel whenever it is possible. This means that when the aneurysm is situated at the lower part of the popliteal space the popliteal artery should be tied above the centre of the space.

Surgical Anatomy.—The popliteal artery extends from the opening in the adductor magnus to the lower border of the popliteus muscle. From its commencement the artery passes obliquely downwards and outwards until it reaches the interval between the condyles of the femur; below this point it descends vertically in the mid-line of the popliteal space.

The artery is deeply placed, and from above downwards *rests on* the popliteal surface of the femur, the posterior ligament of the knee-joint, and the popliteal fascia and muscle. *Posteriorly,* its upper end is covered by the semi-membranosus, and its lower end by the gastrocnemius. The popliteal vein and the internal popliteal nerve cross the artery about its middle, the vein being close to the artery, and the nerve more superficial. The nerves to the soleus and popliteus, and the plantaris muscle are also behind the lower part of the artery. On the *outer* side are the biceps, the external condyle of the femur, the outer head of the gastrocnemius and the plantaris muscle. The internal popliteal nerve and the popliteal vein lie on the outer side of the artery in the upper part of its course.

On the *inner* side are the semi-membranosus, the internal condyle of the femur, and the inner head of the gastrocnemius. The internal popliteal nerve and the popliteal vein are on the inner side of the artery below.

The artery throughout is surrounded by fat, and has several lymphatic glands along it. The guide to its upper part is the outer border of the semi-membranosus, and it bifurcates on a level with the lower part of the tubercle of the tibia.

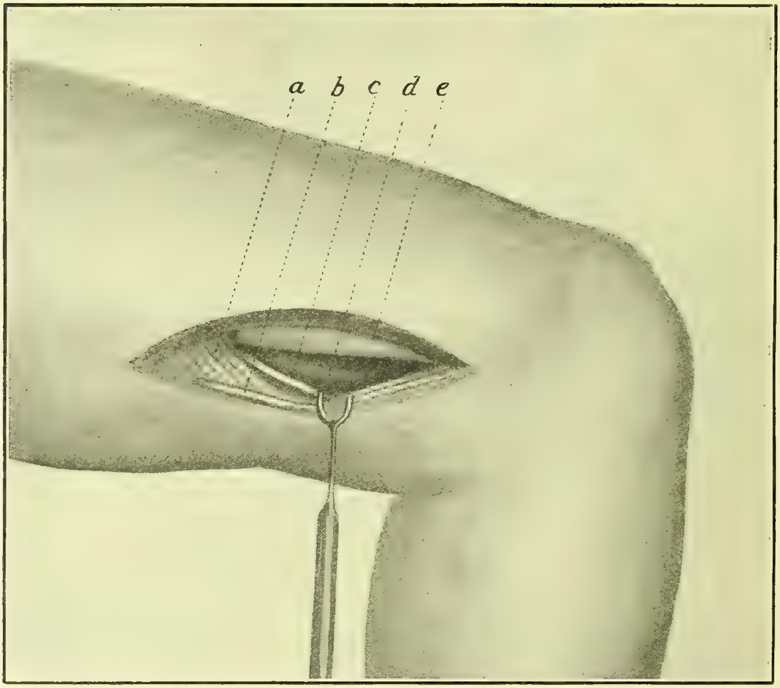


FIG. 104.—LIGATURE OF THE FIRST PART OF THE LEFT POPLITEAL ARTERY. (*a*) Sartorius; (*b*) long saphenous vein; (*c*) long saphenous nerve; (*d*) popliteal artery; (*e*) adductor magnus tendon.

Operation.—The best way to reach the upper part of the popliteal is to cut down upon it from the inner side of the thigh. The limb is placed in the same position as for ligature of the femoral, and the surgeon feels for the adductor tubercle and the tendon of the adductor magnus which is attached to it. He then makes an incision about four inches in length from the adductor tubercle upwards, parallel with the tendon of the adductor magnus, and slightly behind it. After the fascia has been divided, the sartorius will be found running downwards on the inner side of the thigh and overlapping the tendon of the adductor. When this

is pulled downwards and backwards, the tendon of the adductor will be evident, with the hamstring tendons lying behind it. The space between the tendon of the adductor magnus and the hamstrings must be opened, the latter pulled downwards and backwards, and the tendon of the adductor pulled outwards towards the bone. This is facilitated by flexing the knee, when the finger introduced along the posterior surface of the adductor magnus will feel the popliteal artery just after it has passed through the opening in the muscle (see Fig. 104), with the vein to its outer side ; the popliteal nerve is some distance from it. The sheath of the vessel is opened and the needle is passed from without inwards. The operation has the advantage that it gives a better collateral circulation than when the artery is tied higher up ; the risk of gangrene is therefore diminished.

It occasionally happens, especially after proximal ligature at some distance above the sac, that pulsation returns after a few days and the aneurysm continues to increase. Under such circumstances amputation used to be recommended, but now that suppuration can be readily avoided the best procedure is to perform either Matas's or the old operation (*vide infra*). Should the aneurysm become inflamed, should suppuration around the aneurysm occur, or should the latter threaten to burst through the skin, one of these operations should be performed in preference to amputation.

Collateral Circulation after Ligature of the Popliteal Artery.—This is maintained by the superior articular arteries, the anastomotica magna, and the descending branch of the external circumflex anastomosing with the inferior articular arteries and the anterior tibial recurrent. Muscular branches will also aid in maintaining the circulation.

The Old Operation.—The old operation is somewhat difficult in popliteal aneurysm, chiefly on account of the relation of the popliteal vein and the internal popliteal nerve to the artery, and the adhesions between these structures and the sac. The vein and nerve are often considerably displaced by the enlargement of the sac, so that their position is difficult to gauge ; hence the old operation is generally restricted to those cases in which the aneurysm has become diffuse.

A tourniquet is applied around the thigh, and the patient is rolled over almost into the prone position with the affected limb undermost. A free incision is made over the centre of the popliteal space behind, and the internal popliteal nerve is looked for and pulled aside (see Fig. 105). The popliteal vein is identified next and should also be displaced to one side. Should it be difficult to define the vein clearly, an opening should be made into the sac towards the inner side, so as to avoid it if possible. The sac is then incised freely, the clots turned out, and the artery tied above and below the orifice of communication. This can be done more easily if a bougie be introduced through the orifice of the vessel so as to distend it ; it can then be felt, and there is less likelihood

of injury to the vein. A No. 12 bougie fits the lumen of the artery fairly well, and should be pushed up through the opening in the sac until it is felt in the vessel above it, which is then cleared and tied; the bougie is next introduced into the distal portion of the vessel, which is similarly treated. When this has been done, the vein may be identified above and below, and peeled off the sac, after which the latter should be removed *en bloc*. Some of the articular branches of the knee will probably open into the sac, and if these can be recognised they should be tied before the tourniquet is removed, as otherwise considerable bleeding will occur.

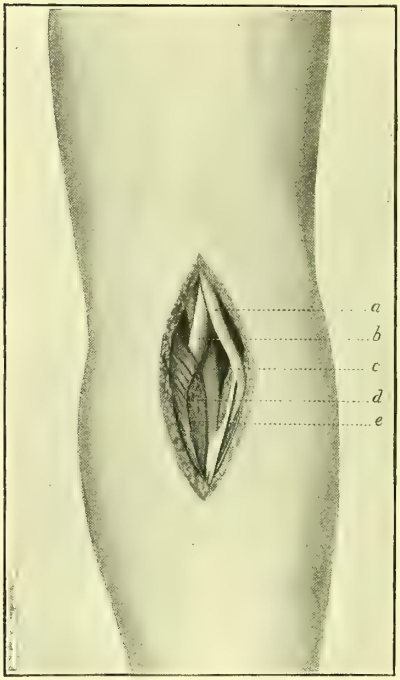


Fig. 105.—Ligature of the Right Popliteal in the Ham. (*a*) Internal popliteal nerve; (*b*) popliteal vein; (*c*) popliteal artery; (*d*) divided fibres of gastrocnemius; (*e*) sural nerve.

Any clots must be turned out of the tissues around; sometimes it may be necessary to clear them out of the knee-joint should the aneurysm have ruptured into it. Even in these cases amputation is not necessary, because the articulation will probably recover perfectly if the operation be performed aseptically. A drainage tube must be inserted into the popliteal space and left in for about ten days, on account of the free oozing which often occurs. The leg should be put on a straight back splint and somewhat elevated, and the same precautions should be taken with the lower extremity as are requisite after ligature of the common femoral (see p. 237).

The operation of endo-aneurysmorrhaphy has been strongly advocated for the treatment of popliteal aneurysm, largely on account of the difficulty of performing the old operation satisfactorily owing to the dense adhesions between the sac and the surrounding tissues which render removal of it dangerous.

Results.—Gangrene is not nearly so likely to occur after the old operation for popliteal aneurysm as after ligature of the femoral artery high up, because the anastomosis is better in the former operation. The anastomotica magna carries a large volume of blood to the articular arteries and the recurrent branches of the tibial.

GLUTEAL ANEURYSM.

This is not of common occurrence, and may be either spontaneous or traumatic, generally the latter.

TREATMENT.—The best treatment is ligature of the internal iliac vessel. Before deciding upon the precise operation it is very important to make an examination *per rectum* or *per vaginam* in order to ascertain the exact position of the aneurysmal sac.

Ligature of the Internal Iliac Artery.—When the aneurysm encroaches upon the pelvis, ligature of the internal iliac artery must be employed. This can be done either by a trans-peritoneal incision or by an *extra-peritoneal operation.* The earlier steps of these operations are the same as those described (see p. 224) for ligature of the external or common iliac trunk. The ureter must be carefully avoided and the needle passed from above downwards, so as to avoid the internal iliac vein which lies behind and to the inner side of the artery. In the *trans-peritoneal operation* special care must be taken in passing the ligature to avoid including the ureter, which crosses the vessel in front, but which is, however, usually turned forwards with the peritoneum. A good light is essential for success, as the separation of the artery from the large internal iliac vein has to be done very carefully.

Surgical Anatomy.—The internal iliac artery is covered by the peritoneum under which the ureter descends. On the left side the large intestine (ilio-pelvic colon) crosses from the front to the inner side of the artery, and on the right side the termination of the ileum has a similar relation. The internal iliac vein, the lumbo-sacral nerve and the sacrum are in close relation to the artery posteriorly, while the external iliac vein separates it from the psoas muscle, and the obturator nerve lies between the artery and the lateral wall of the pelvis below the vein.

Collateral Circulation after Ligature of the Internal Iliac Artery.—This is accomplished by the anastomosis of the middle sacral with the lateral sacral; the inferior hæmorrhoidal with the superior hæmorrhoidal; the circumflex iliac with the ilio-lumbar and lumbar arteries; the branches of the profunda femoris with those of the sciatic and gluteal; the internal pudic, vesical, and hæmorrhoidal with those of the opposite side.

The two following operations are described because they are sometimes practised on the cadaver; they are practically obsolete in surgery.

Ligature of the Gluteal Artery.—*Surgical Anatomy.*—This vessel emerges from the pelvis through the upper part of the great sacro-sciatic notch above the pyriformis muscle, its point of exit corresponding to the junction of the upper and middle thirds of a line drawn from the posterior superior iliac spine to the tip of the great trochanter when the thigh is slightly flexed and rotated inwards.

The gluteal artery at once divides between the pyriformis and gluteus muscles, beneath the gluteus maximus, into a superficial and deep branch. The former,

dividing into numerous branches, supplies the gluteus maximus: the latter runs forwards with the superior gluteal nerve between the gluteus medius and minimus and divides into upper and lower branches.

Operation.—The patient is rolled over upon the unaffected side, and an incision four inches in length, with its centre over the point of emergence of the artery, is made along the line of the vessel. This incision will run parallel with the fibres of the gluteus maximus, which must be separated and pulled apart with retractors. The interval between the pyriformis muscle below and the gluteus medius above is sought for, and these muscles are separated and held apart. The finger then seeks for the upper edge of the sacro-sciatic notch, upon which the gluteal artery will be found beating (see Fig. 106). The vessel is isolated and a ligature applied; care should be taken to tie it as far back as possible, because the artery divides into branches soon after its exit from the pelvis. After the vessel has been ligatured,

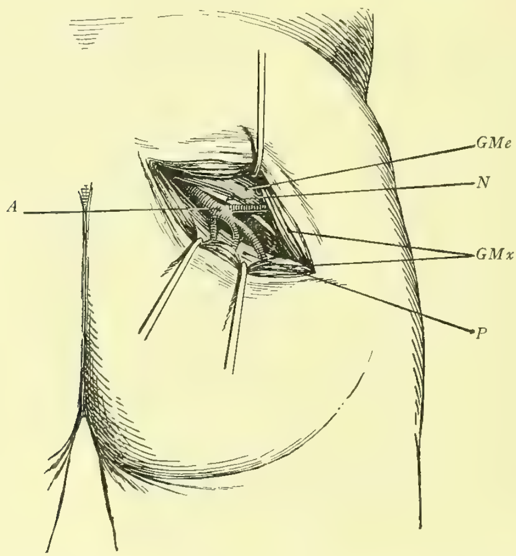


FIG. 106.—LIGATURE OF THE RIGHT GLUTEAL ARTERY. *GMx.* Gluteus maximus. *GMe.* Gluteus medius. *P.* Pyriformis. *A.* Obturator artery. *N.* Superior gluteal nerve.

the aneurysmal sac should be opened, the clots turned out, and the wall dissected away as completely as possible.

Ligature of the Internal Pudic Artery in the Buttock.—This artery emerges from the pelvis through the lower part of the great sacro-sciatic notch, winds round the spine of the ischium and passes to the front of the innominate bone through the lesser sacro-sciatic notch. The artery is tied as it lies on the posterior surface of the spine of the ischium, and this point corresponds with the junction of the lower with the middle third of a line drawn from the posterior superior iliac spine to the ischial tuberosity.

An incision is made somewhat obliquely to this line parallel to the fibres of the gluteus maximus and with its centre corresponding to the ischial spine. After the skin and fascia have been divided, the fibres of the gluteus maximus are separated and held apart. This shows the lower border of the pyriformis muscle with the tendon of the obturator internus below it. The vessel will be found as it passes around the spine with the nerve lying to its inner side.

ANEURYSMS OF THE LEG AND FOOT.

These are not at all common ; they are generally situated on the posterior tibial artery, but may be met with on the peroneal or the anterior tibial. In the foot aneurysms are exceedingly rare, and are generally traumatic, the most common situation being on the dorsalis pedis. The best treatment of these aneurysms, as a rule, is to extirpate them entirely. The methods of exposing the arteries concerned are given below.

Ligature of the Anterior Tibial Artery.—*Surgical Anatomy.*—This artery descends from the lower border of the popliteus muscle to the centre of the front of the ankle-joint. Its course is indicated by a line drawn from a point midway between the outer tuberosity of the tibia and the head of the fibula to another point on the front of the ankle, midway between the two malleoli.

The artery is deeply placed above, and, as it descends, it inclines inwards towards the tibia, crossing the front of the lower third of that bone and becoming superficial. It rests upon the interosseous membrane, the anterior surface of the tibia, and the anterior ligament of the ankle-joint. In the upper third of the leg, it lies between the extensor longus digitorum and the tibialis anticus ; in the middle third it lies between the latter muscle and the extensor longus hallucis, and in the lower third it is between the tendon of the extensor longus hallucis and the innermost tendon of the extensor longus digitorum. The anterior tibial nerve is at first to the outer side of the artery, then in front of its middle third, and finally it again passes to its outer side, separating the artery from the innermost tendon of the extensor longus digitorum. Two venæ comites accompany the artery, and anastomose freely across it at short intervals.

This vessel may be tied at any part of its course. The operation is most frequently done in the upper or the lower third. The leg should be adducted and rotated somewhat inwards, and the hip and knee joints somewhat flexed.

In the Upper Third.—An incision four inches long should be made over the line of the artery, commencing about an inch below the external tuberosity of the tibia. After division of the skin and fascia, the outer edge of the tibialis anticus is looked for, and the inter-muscular septum between this muscle and the extensor longus digitorum is opened up. While this is being done, it is well to raise the toes so as to relieve the tension upon the muscles, and to enable them to be separated more easily. The artery lies upon the interosseous membrane at the bottom of this space immediately after it has passed to the front of the leg. The anterior tibial nerve is not always seen in the operation, as it may reach the outer side of the artery somewhat lower down (see Fig. 107).

The only difficulty in the operation is to choose the right inter-muscular septum (viz. the innermost), and not to explore the one between the extensor longus digitorum and the peroneus longus.

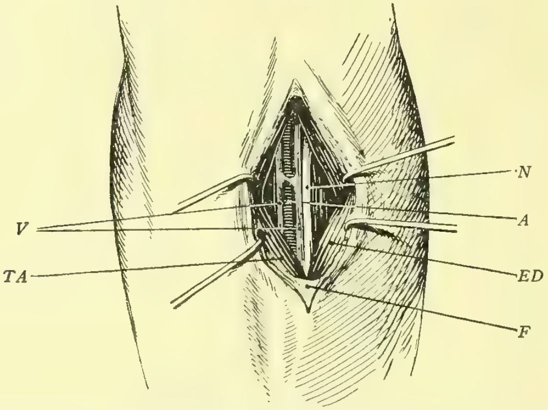


FIG. 107.—LIGATURE OF THE LEFT ANTERIOR TIBIAL IN THE UPPER THIRD. *TA.* Tibialis anticus. *A.* Anterior tibial artery. *V.* Venæ comites. *ED.* Extensor longus digitorum. *N.* Anterior tibial nerve. *F.* Fascia lata.

In the Lower Third.—An incision is made in the line of the artery along the outer edge of the tendon of the tibialis anticus muscle, which is the first prominent tendon external to the anterior border of the tibia. The skin and fascia are divided, and this tendon is drawn inwards, whilst the next (that of the extensor longus hallucis) is drawn outwards; the artery will then be seen, with the anterior tibial nerve to its outer side and rather in front of it (see Fig. 108). The tendon sheaths should not be opened.

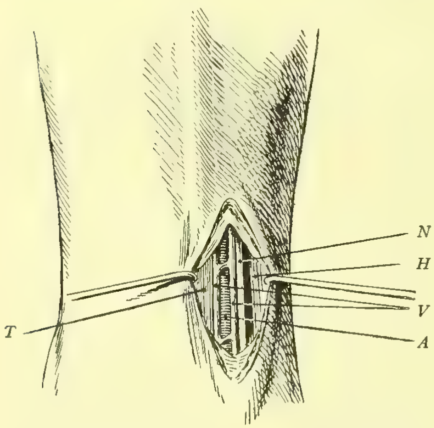


FIG. 108.—LIGATURE OF THE LEFT ANTERIOR TIBIAL IN THE LOWER THIRD. *T.* Tibialis anticus tendon. *A.* Anterior tibial artery. *V.* Venæ comites. *H.* Extensor longus hallucis tendon. *N.* Anterior tibial nerve.

Collateral Circulation after Ligature of the Anterior Tibial Artery.—This is maintained by the dorsalis pedis anastomosing with the internal and external plantar arteries; by the internal malleolar with the corresponding artery of the posterior tibial; the external malleolar with the anterior peroneal and tarsal branch of the dorsalis pedis; and by muscular branches which pierce the interosseous membrane.

Ligature of the Dorsalis Pedis Artery.—*Surgical Anatomy.*—This artery is the direct continuation of the anterior tibial, and its position is indicated by a line from the centre of the ankle-joint to the posterior end of the first interosseous space.

It is covered superficially by the skin and fascia, and is crossed near its termination by the innermost tendon of the extensor brevis digitorum. Its upper part is beneath the lower edge of the anterior annular ligament. It rests upon the anterior ligament of the ankle-joint, the head and neck of the astragalus, the scaphoid and the ligaments connecting these bones, the internal cuneiform and the ligaments between the inner and middle

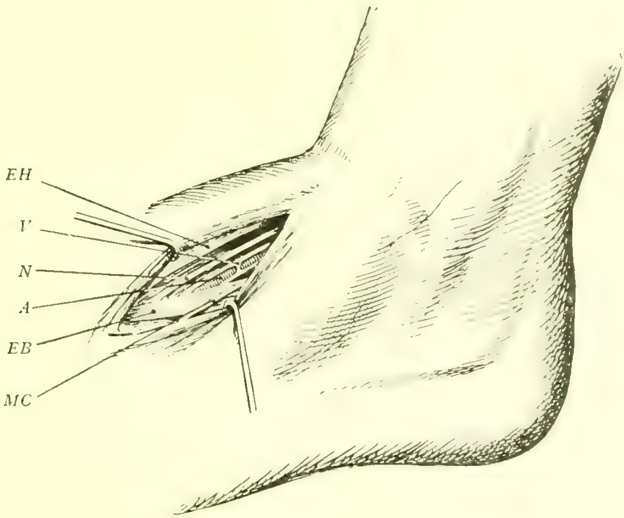


FIG. 109.—LIGATURE OF THE LEFT DORSALIS PEDIS. *EH.* Extensor longus hallucis tendon. *A.* Dorsalis pedis. *EB.* Extensor brevis digitorum innermost tendon. *N.* Anterior tibial nerve. *MC.* Musculo-cutaneous nerve. *V.* Venæ comites. The anterior tibial nerve usually lies to the outer side of the artery.

cuneiform bones. On its inner side is the tendon of the extensor longus hallucis, and on its outer side is the innermost tendon of the extensor longus digitorum and the anterior tibial nerve. There are two venæ comites, one on either side of the vessel.

Operation.—The artery may be tied either at the ankle-joint or further down in its course. The foot is extended and an incision is made along a line from the mid-point between the two malleoli to the upper end of the first interosseous space. After division of the skin and fascia the tendon of the extensor longus hallucis will be seen internally with the innermost tendon of the extensor longus digitorum running forwards and inwards on its outer side. The artery lies in the angle formed by these two tendons, and by pulling the latter inwards and outwards, the artery is

at once exposed with the anterior tibial nerve upon its outer side (see Fig. 109).

Ligature of the Posterior Tibial Artery.—*Surgical Anatomy.*—This vessel is placed between the superficial and deep calf muscles, to the latter of which it is closely connected by the deep transverse fascia. It commences on a level with the lower part of the tubercle of the tibia, and bifurcates into the internal and external plantar arteries on a level with a line drawn from the tip of the internal malleolus to the centre of the convexity of the heel. As it passes downwards, the artery inclines

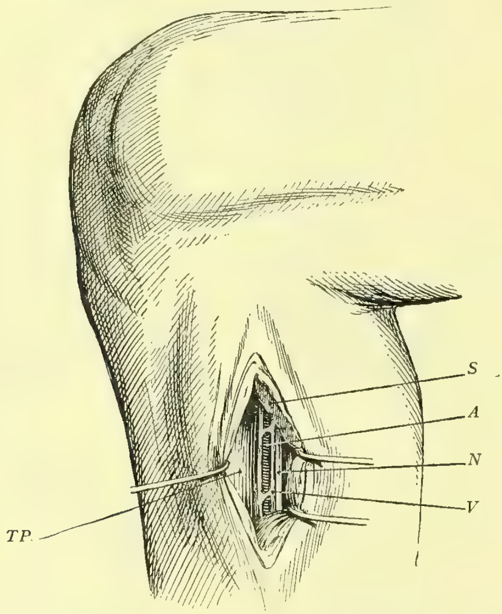


Fig. 110.—Ligature of the Right Posterior Tibial in Upper Third. *S.* Soleus, showing cut surface. *A.* Posterior tibial artery. *V.* Venæ comites, *TP.* Tibialis posticus. *N.* Posterior tibial nerve.

inwards, and lies successively on the tibialis posticus, the flexor longus digitorum, the posterior aspect of the tibia, and the back of the ankle joint. It is covered by the special deep fascia which binds down the deep muscles, and in the upper part by the gastrocnemius and the soleus, with the plantaris between them. The lower half of the artery is superficial, and is covered by the skin and fascia, except at its termination, where the internal annular ligament and the origin of the abductor hallucis cover it. The posterior tibial nerve is at first on the inner side; it then crosses the artery about an inch from its commencement, and for the rest of its course lies on the outer side. There are two venæ comites, one on each side of the vessel; they anastomose freely across it.

The course of the artery is indicated by a line from the centre of the

popliteal space to a point midway between the tip of the internal malleolus and the prominence of the heel.

In the middle of the leg the artery may be exposed by an incision behind the inner border of the tibia. The limb is laid upon its outer side, with the knee flexed and supported upon a sandbag, and an incision about four inches long is made parallel to the inner border of the tibia and about a finger's breadth behind it. The internal saphenous nerve and vein are generally exposed and must be pulled aside. After the deep fascia has been divided, the inner border of the gastrocnemius comes into view and is drawn back with a retractor. The oblique fibres

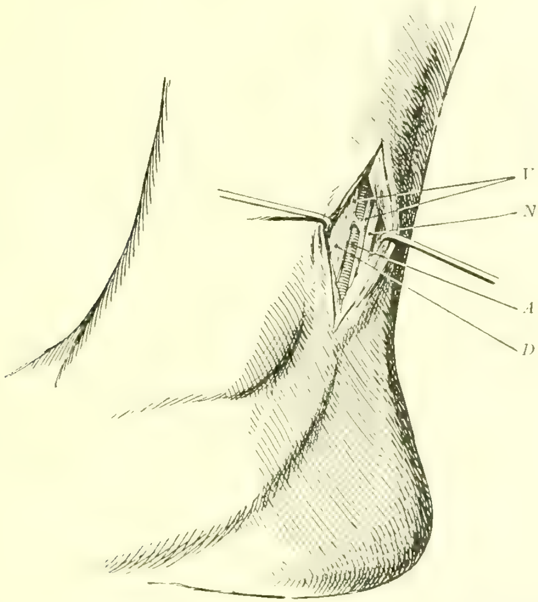


FIG. 111.—LIGATURE OF THE RIGHT POSTERIOR TIBIAL IN LOWER THIRD. *D.* Flexor longus digitorum tendon. *A.* Posterior tibial artery. *N.* Posterior tibial nerve. *V.* Venæ comites.

of the soleus arising from the tibia are then seen, and must be divided in the line of the incision until the glistening fascia near the anterior surface of the muscle is exposed. This is divided in the same direction, when the muscular fibres of the flexor longus digitorum are seen with the tibialis posticus to its outer side, and still more externally the flexor longus hallucis. The artery will be found between the flexor longus digitorum and the tibialis posticus, about an inch and a quarter beyond the inner border of the tibia. The posterior tibial nerve is on its outer side (see Fig. 110).

Difficulties.—Two mistakes are often made. Either the soleus is divided too far outwards, and the finger passes outside the tibialis posticus

muscle, or after dividing the soleus the flexor longus digitorum is separated from the tibia, so that the finger passes inside that muscle and away from the artery.

Behind the inner ankle the artery lies midway behind the tendo Achillis and the inner border of the tibia, and as it curves behind the internal malleolus it keeps about the same distance from the edge of the bone. A curved incision, with its concavity forwards, is made a finger's breadth behind the internal malleolus, when the vessel is exposed after division of the annular ligament. Between the malleolus and the artery lie the tendons of the tibialis posticus and the flexor longus digitorum, whilst behind the vessel is the posterior tibial nerve, and behind that again the tendon of the flexor longus hallucis (see Fig. 111). The principal mistake made in tying this artery is to get too far back towards the tendo Achillis.

Collateral Circulation after Ligature of the Posterior Tibial Artery.—This will be carried on by the communicating and muscular branches of the peroneal and posterior tibial; the dorsalis pedis with the external plantar; the external calcaneal of the peroneal with the internal calcaneal of the external plantar; the internal malleolar with the corresponding branch of the anterior tibial; and muscular branches which pierce the interosseous membrane.

Ligature of the Peroneal Artery.—*Surgical Anatomy.*—This artery is the largest branch of the posterior tibial. It arises about an inch below the lower border of the popliteus muscle, and passes obliquely outwards to the fibula, descending along the inner border of that bone to the lower third of the leg, where the anterior peroneal artery is given off; the main trunk then passes across the articulation between the tibia and the fibula as the posterior peroneal artery.

The vessel rests first on the tibialis posticus muscle, and, for the greater part of its course, it is contained in a fibrous canal between the origins of the flexor longus hallucis and tibialis posticus. It is covered by the deep transverse fascia and the soleus and flexor longus hallucis. Two venæ comites accompany this vessel.

The course of this vessel is sufficiently indicated by a line drawn from just above the middle of the calf along the inner border of the posterior surface of the fibula. The line usually given for the incision for tying the vessel is from the posterior border of the head of the fibula to a point midway between the external malleolus and the tendo Achillis. The artery is generally tied in the lower third, but it can be tied in the upper third near its origin through the incision made for ligature of the posterior tibial in that situation (see p. 250). In ligaturing it in the lower third, an incision is made in the line of the vessel, the deep fascia divided and the outer border of the soleus muscle exposed and drawn inwards. Beneath this are seen the fibres of the flexor longus hallucis covered by a tendinous expansion. On separating the flexor longus hallucis from the posterior surface of the fibula the artery is found at the outer border of the tibialis posticus muscle.

DIVISION II.

THE SURGICAL AFFECTIONS OF THE BONES.

SECTION I.—FRACTURES.

CHAPTER XIV.

GENERAL CONSIDERATIONS.

DEFINITION.—By a fracture is understood a sudden solution of continuity in a bone brought about by some form of violence. Before dealing with fractures of individual bones, it will be well to discuss the chief points in connection with fractures in general.

CAUSES.—It is usual to divide the causes of fracture into the exciting causes—that is to say, the actual violence producing the fracture—and the various predisposing causes which lead to brittleness of the bones and a liability to fracture upon the application of even a slight degree of force. These predisposing causes are important, because, when they exist, the treatment must be directed to combating them as well as to replacing the fragments and keeping them in position.

Exciting Causes.—When violence is applied to a bone, a fracture may occur directly opposite the seat of injury—when the fracture is termed one by *direct violence*—or it may take place at some distance from the point of application of the force—when it is spoken of as one by *indirect violence*. The question as to whether a particular fracture is caused by direct or indirect violence is of importance both in prognosis and treatment. As a result of indirect violence, the line of fracture is often oblique or spiral, and there is frequently difficulty in reducing the fracture

and keeping the fragments in proper position. When, on the other hand, the fracture is caused by direct violence, it is usually transverse or comminuted, and there is often considerable injury to the soft parts in the neighbourhood of the fracture as well.

Fractures from indirect violence may be produced in several ways. It is very common for the ends of the bone to be compressed between two opposing forces, and for fracture to take place at some intermediate point from a bending of the bone which is carried beyond its limit of elasticity ; in the long bones the resulting fracture usually occurs at the weakest part of the bone, namely, the junction of the expanded articular end with the comparatively narrow shaft. In other cases, fractures by indirect violence may be brought about by unduly forcible or irregular muscular contraction, or by muscular contraction of normal strength in those who suffer from some pathological condition of the bones. Fracture of the patella is an example of fracture resulting from irregular and forcible contraction of the quadriceps extensor when the knee is bent, the patella being snapped across the condyles of the femur as a stick is broken across the knee.

Predisposing Causes.—There are numerous pathological conditions which produce a liability to fracture, and so act as predisposing causes. It will suffice to enumerate the most important. The commonest are new growths of bone, especially secondary carcinoma, and the osseous changes associated with locomotor ataxia. In addition there are senile changes in the bone structure, fragilitas ossium, mollities ossium, scurvy-rickets, insanity, atrophy of bone, and the inflammatory conditions that lead to extensive necrosis or rarefying osteitis. When a fracture has been produced by comparatively slight violence, one of these causes should be carefully searched for, and, if found, appropriately treated.

CLASSIFICATION.—Fractures are variously classified ; for our purposes they may be divided into three great classes : Simple, Compound, and Complicated.

A Simple fracture is one that does not communicate with the exterior and is uncomplicated by injury to important structures in its neighbourhood. It is not liable to septic complications, and, with few exceptions, unites readily.

A Compound fracture is one that communicates with the exterior through a laceration of a cutaneous or mucous surface. These fractures may be compound from the first ; communication with the exterior may occur simultaneously with the fracture, either as a result of the soft parts being divided down to the bone, or from the broken ends of the bone being forcibly protruded through the skin or mucous membrane. On the other hand, a fracture may be simple at first, and may afterwards become compound, either owing to the bone working its way through the tissues as a result of movement, or owing to the occurrence of suppuration or gangrene in the parts over the broken ends

A Complicated fracture is one that is associated with some other injury such as a wound in the skin not communicating with the bone, or injuries to vessels, nerves or joints.

Fractures are still further subdivided according to the variations in direction of the line of fracture, as *transverse*, *oblique*, and *spiral* fractures. When the bone is broken up into a number of small pieces, the term *comminuted* fracture is usually applied. In *multiple* fractures there is either more than one fracture in an individual bone, or more than one bone broken. In an *impacted* fracture one end of the broken bone is driven into, and, to a certain extent, splits up the other fragment. A *greenstick* fracture is one in which, owing to the bone being softer and less brittle, the fracture is incomplete, some of the fibres being torn, while others are merely bent.

Epiphyseal Separation.—Besides these forms of true fracture there is the injury known as 'separation of the epiphysis,' which is met with most commonly in childhood, but which may occur up to the age of twenty-five. It is rare for the plane of separation to be confined to the epiphyseal cartilage, as the term suggests; the line of fracture generally runs through the spongy layer of the shaft immediately in contact with the epiphysis. Sometimes there are only a few bony spicules left attached to the separated epiphysis, but more commonly there are definite bony plaques, or the plane of fracture may leave the diaphyseo-epiphyseal junction and run for a considerable distance in the shaft of the bone.

There are other forms of fracture of slight importance, from the point of view of treatment, which occur especially in the flat bones; the commonest are fissures, indentations, starred and depressed fractures.

DISPLACEMENT.—When a bone undergoes fracture, the fractured ends are generally displaced upon one another; it is comparatively rare for a fracture to be unaccompanied by any displacement. The chief displacements are *angular* displacements, in which the fragments are inclined at an angle to each other; *lateral* displacements, in which the fractured ends remain in apposition to some extent, but are displaced to the side; *riding* or *overlapping* of the fragments, which is especially common in oblique fractures, one fragment being pushed up in front of or behind the other; *rotation* of one fragment around its vertical axis; and *separation* of the fragments, which is most often seen in fractures of the patella and the olecranon.

The displacement in a fracture is due to the force which produces the injury, to the contraction of muscles inserted into the fragments, or to the weight of the limb. In most cases the primary displacement is determined by *the direction and force of the injury* producing the fracture. The displacement is comparatively slight in fractures due to direct violence, whilst it is very marked in those produced by indirect violence. This shows that primarily, at any rate, it is not due so much to muscular contraction as to the direction of the force. On the other hand, in most

cases the displacement is maintained or exaggerated by *the contraction of the muscles*, whilst sometimes it may even be due entirely to this cause. *The weight of the limb* is also an important factor in the production of displacement especially in fractures of the lower extremity; in these cases, unless proper support be given to the foot, the latter rotates outwards, carrying with it the limb below the fracture, and outward rotation of the lower fragment is produced.

PATHOLOGICAL CHANGES.—When a bone is broken, there is always bruising or tearing of the soft parts about it. The periosteum is almost invariably torn through, although in children it may occasionally remain intact to a large extent. Usually, however, it gives way immediately above or below the seat of fracture. This is important to remember, because the free ends of the torn periosteum may become interposed between the fractured surfaces, and non-union may result. The muscles attached to the bone in the immediate neighbourhood of the fracture are torn, and the fractured ends still further tear up the tissues if there be much displacement. The result is a considerable effusion of blood, which coagulates. When the ends of the bone are brought into apposition, they are therefore separated to some extent by a layer of clot, and they are surrounded by a mass of coagulated blood, in which are entangled torn portions of the periosteum, the muscles, and other soft tissues. In a simple fracture this clot remains and forms a mould in which the processes of repair take place.

REPAIR OF FRACTURES.—**In a Simple Fracture.**—It is unnecessary to do more than indicate the gross changes which take place when a fracture undergoes repair. The greater part of the blood extravasated between the ends of the bone is absorbed, but a certain amount is replaced by granulation tissue, which, in its turn, is replaced by fibrous tissue containing nodules of cartilage and newly formed unossified bone or osteoid tissue. This mass of newly-formed tissue welds together the fragments and is known as 'callus'; it can be felt as an irregular fusiform swelling at the site of the fracture. That part of the callus lying between the fragments becomes converted into bone and forms a permanent uniting medium; hence it is called the 'permanent' or 'definitive' callus. The remainder, including the portion with the medullary canal called 'the provisional callus,' is destined to become absorbed.

In a Compound Fracture.—When a fracture is compound or is treated by an open operation, the amount of provisional callus is usually very scanty; and since the function of this structure is to fix the bones together while ossification is in progress, union may be correspondingly delayed.

In septic compound fractures the fractured surfaces and the tissues around become converted into granulation tissue, so that the opposing surfaces of the bone are soon covered by granulations, provided that no necrosis or osteo-myelitis occurs. These granulations coalesce, and ossification takes place in them.

In Epiphyseal Separation.—As a general rule union takes place as in a simple fracture, whether the plane of fracture be in the cartilage or in the adjacent bone. There is a risk, however, that the injury to the growing cartilage may interfere with the subsequent development of the bone.

THE TREATMENT OF SIMPLE FRACTURES.

There are four important indications to attend to in the treatment of any case of fracture :—

1. To bring the ends of the bone level with one another, or Reduction.

2. To get the ends into accurate apposition, or Coaptation. (These two manipulations are included under the term 'setting the fracture.')

3. To maintain the ends of the bones in apposition until union has taken place, or Immobilisation.

4. To promote the nutrition of the part, and to prevent adhesions in neighbouring joints and muscles.

THE REDUCTION AND COAPTATION OF FRACTURES.

These two processes may be considered together. Their object is to bring the ends of the fractured bone together, and to place them in accurate apposition, so that union may take place with the least possible deformity. Reduction and coaptation of a fracture are necessary whenever there is any displacement. Sometimes, as in fractures of the metacarpus or the jaw, this may be done by simple manipulation with the fingers, aided, if necessary, by the administration of an anæsthetic ; but mere manipulation will not suffice in the great majority of fractures affecting the long bones. The fractured ends generally overlap to some extent, and the muscles are contracted and offer resistance to the manipulations. Hence it is necessary to employ extension of the limb by traction in order to bring the ends of the bone to the same level before the manipulations requisite for the proper coaptation of the broken ends can be practised.

In practically all cases except fractures of small bones it is advisable to administer an anæsthetic in order to set the fracture. Anæsthesia not only relieves pain and shock, but, by abolishing muscular contraction, it allows coaptation to be secured with the minimum amount of damage to the soft parts.

A fracture has not been properly coapted if the overlapping recurs when the traction necessary to ensure reduction is relaxed. With rare exceptions the broken surfaces are jagged and should interlock when the fracture has been set properly, and the case should not be left until this object has been attained. Extension alone will not maintain the reduction. On the other hand, very little force is required to prevent displacement when once the fracture has been properly coapted. Manipulations

must be employed during coaptation in order to interlock the fractured surfaces. A frequent cause of failure in coaptation is that the surgeon forgets the spiral nature of the fracture, and does not rotate the fragments sufficiently to get accurate apposition.

Employment of the X-rays.—The X-rays are most useful both in the diagnosis and the treatment of fractures. Not only are they of the greatest value in determining the exact nature of a fracture and in ascertaining whether the fractured ends remain in position after the fracture has been set, but in many cases they are invaluable during coaptation of the fracture. The necessary manipulations can be carried out with the aid of the fluorescent screen, and the surgeon can see not only when the fracture is accurately set, but also the most advantageous direction in which to manipulate the fragments so as to get the ends into position. In certain fractures in the neighbourhood of the articular surfaces, this is almost the only way in which the surgeon can make sure that he has obtained satisfactory coaptation.

In this connection we would emphasise the importance of the X-ray work being done by a medical man, as it requires a good general knowledge of fractures to be able to take radiograms that shall demonstrate the points in a particular fracture that the surgeon desires to know. Stereoscopic views are necessary in a large number of cases, since no other view will show the frequently spiral nature of these fractures so well; but direct examination of a fracture by means of the fluorescent screen is valuable since the limb can be moved in any direction and the fracture examined from all points of view, and the direction and extent of the manipulations necessary for coaptation ascertained. This examination should never be omitted if it can be practised, and with a suitable couch it is easy to apply it to most fractures.

After coaptation has been secured, and the limb has been put up in splints, a stereoscopic radiogram should be taken as soon as possible, in order to see that the position remains good. If this be so, there is little chance of the ends of the fractured bones becoming displaced unless some obvious cause of displacement should arise.

Extension and Counter-extension.—Assistance is necessary for the proper reduction of a fracture in a long bone, and, if the patient be very muscular, two assistants will be required. If only one be at hand, he should exert counter-extension, that is to say, he fixes the upper fragment or the trunk while the surgeon effects the extension; it is not necessary to have a skilled assistant for this purpose. When no assistant is available, counter-extension may be obtained by fixing the body of the patient to the bed, whilst the surgeon makes the necessary extension and manipulations. The lower fragment should be seized with one hand well below the seat of the fracture; the other grasps the region of the fracture, and manipulates the bones into position when the lower fragment has been pulled down sufficiently. If two assistants be present

one should make extension and the other counter-extension ; the surgeon can then devote all his attention to the coaptation of the fractured ends.

The extension should be steady, gradual, and in the long axis of the bone. Sudden jerky movements lead to contractions of the muscles that oppose the reduction; while, if slowly and steadily stretched, the muscles gradually become tired out, and their resistance ceases.

The administration of an anæsthetic during reduction should be insisted upon, unless there be some distinct contra-indication; muscular contraction will then be completely overcome, and the fractured ends can be brought into accurate apposition, while the apparatus for maintaining them in position can be applied before the patient is allowed to come round. It is important to see that the limb is immobilised during the induction of the anæsthesia, and special care must be taken that no involuntary movements of the limb occur. Much damage may be done to the soft parts, and a simple fracture may be converted into a compound one, by a neglect of this precaution, which is especially important in alcoholic subjects.

Obstacles to Reduction.—The chief obstacles to reduction are:—

Spasm of the muscles, which is readily overcome by the administration of an anæsthetic.

The presence of impaction, one fragment being driven into the other. It may be difficult to disentangle the ends and to bring them into proper position, but in most cases this should be done. There are a few instances, however, in which impaction is of advantage, and should not be interfered with, *e.g.* in fracture of the neck of the femur in old people. In Colles's fracture, on the other hand, any impaction present should be undone as soon after the injury as possible, otherwise the hand may be permanently disabled by a bony deformity and a displacement of the articular surface that cannot be remedied subsequently without operation.

The presence of loose fragments about the fracture may impede accurate coaptation particularly in fractures in the immediate vicinity of joints ; in them the greatest care must be taken to manipulate the loose fragments under anæsthesia so as to secure proper coaptation. If this be impossible —as it often is in fractures in the neighbourhood of the elbow-joint—the surgeon should not hesitate to expose the seat of fracture, and either remove the loose fragments or fix them in position. Attempts to get union with a loose fragment in bad position end either in non-union or in consolidation of the fracture accompanied by deformity and functional impairment of the limb, which requires for its rectification an operation at a later date and under less favourable conditions. The treatment of individual cases of this kind is described in connection with special fractures.

Portions of muscle, tendon, or fascia may be interposed between the fragments, and, if allowed to remain, may cause union either to fail entirely, or to be imperfect and accompanied by deformity. If it be found that the interposed structures cannot be satisfactorily pushed aside after

thorough manipulation under an anæsthetic, it is best to cut down upon the fracture, disentangle the ends of the bones, and secure them in position.

Time for effecting Reduction.—Reduction and coaptation of a fracture should always be effected as soon as possible after the accident, and, if possible, before marked effusion has occurred; the surgeon is then able to ascertain satisfactorily whether he has brought the ends of the bones into apposition. Moreover, as the effusion is largely due to hæmorrhage resulting from laceration of the tissues by the broken ends of the bone, the sooner these are immobilised the less will be the effusion. Lastly, when an anæsthetic is not to be used for the purpose, it is easier to effect reduction immediately after the occurrence of the fracture, because the patient is suffering from shock, and hence there is less rigidity and less difficulty in bringing the ends of the bone into apposition, while at the same time he does not appreciate the pain as much as he does after the shock has passed off. It has been customary to describe cases in which immediate reduction is not to be attempted, and in which some time should be allowed to elapse before the fracture is reduced—for example, those in which there is great swelling about the fracture or excessive spasm (as in cases of incipient delirium tremens). The same line of treatment is recommended when some time has elapsed since the occurrence of the fracture and there is great swelling. But in all these cases there would be less trouble in reducing the fracture, less pain caused to the patient, and less likelihood of the occurrence of local troubles if the broken ends were brought into position at once. Fresh swelling will not occur, because the ends of the bones will be at rest; spasm can be readily overcome by an anæsthetic, and the limb can be so put up that the fracture cannot be subsequently displaced, even by the most violent movements. The longer the time allowed to elapse between the injury and the reduction of the fracture, the greater will be the difficulty in effecting it, because of the rapid consolidation of the effusion that has been poured out, and the consequent difficulty of stretching the soft parts sufficiently to get the ends of the bone into apposition.

When a fracture is reduced, it should be done once and for all, and the surgeon should then immediately proceed to apply some form of retentive apparatus designed to immobilise the parts. Should suitable fixation apparatus not be at hand when the surgeon first sees the case, he should content himself with applying some form of temporary fixation to the fragments, without making any attempt to bring them into apposition. Then, as soon as possible, he should complete his arrangements for the reduction of the fracture and the permanent maintenance of the broken ends in position. To attempt a partial reduction in the first instance, to apply a temporary splint, and then to come back again and repeat the reduction before applying a permanent one is to lacerate the tissues twice instead of once, and to cause a much greater effusion than would result if the advice we have just given were followed.

MAINTENANCE OF REDUCTION.

Two points must be borne in mind in maintaining the fragments in position after reduction. In the first place, the limb should be placed in a position that will minimise the action of all the muscles that can pull upon the fragment and reproduce the displacement ; in the second place, some form of apparatus must be employed to fix the bones immovably in proper position.

Position of the Limb.—The limb should be placed in such a position that the muscles which pull upon the broken fragments are relaxed as much as possible. This is better than attempting to control muscular action by the application of powerful splints and tight bandages. In determining the position which a limb should be made to assume when a bone is broken near one extremity, it should be remembered that it is more difficult to act upon the short fragment than upon the long one and the shorter the fragment the more difficult it is to keep it in proper position. Hence a good axiom, and one that applies more especially to fractures of the lower extremity, is that the position of the limb during repair should be so arranged that the long fragment is brought into line with the short one, and not *vice versâ*. For example, in a fracture of the femur below the lesser trochanter, the short upper fragment is tilted forwards, rotated outwards and abducted, and it is impossible with any form of apparatus to maintain the short fragment in the horizontal position and prevent its outward rotation. Hence, in putting up such a fracture, the long axis of the lower fragment must be made to coincide with that of the upper one—in other words, the thigh must be flexed, abducted and rotated outwards.

In this connection it may be mentioned that, in spite of careful attention to position, the muscular contraction may be so great as to keep up the displacement, and, therefore, it may be advisable to divide tendons in order to neutralise the pull of the muscles. This is sometimes necessary in fractures about the ankle, where the gastrocnemius pulls back the lower fragment in spite of flexion of the knee.

Retentive Apparatus.—After the fracture has been reduced, measures must be taken to keep the fragments in apposition until consolidation has occurred. In some fractures, such as those of the skull and the upper jaw, in which there is no likelihood of a recurrence of the displacement after reduction, these measures are not necessary. The following are the chief methods in use : (1) Bandages and strapping ; (2) splints of various kinds, including immovable apparatus made of plaster of Paris, etc. ; (3) extension in its various forms ; and (4) operative interference designed to fasten the fragments together mechanically.

Bandages and Strapping.—These are chiefly employed in fractures involving the trunk. In fractures of the clavicle, for example, and in certain fractures of the jaw, no splints are required, bandages or strapping

being sufficient to secure proper coaptation and immobilisation. In fractures of the ribs also, strapping applied to the chest suffices to ensure sufficient immobilisation. In fractures of the extremities this method is rarely sufficient, although in certain instances such as fractures of one metacarpal or metatarsal bone, where the neighbouring bones can be made to act as efficient splints, a bandage is all that is necessary to keep the parts at rest.

The exact manner in which bandages and strapping should be applied will be described in connection with the particular fractures for which they are employed. We may mention here that it should be a cardinal rule in most cases (the chief exception being fracture of the ribs) that the *bandages or strapping should not be put over the actual seat of fracture.* This is important for two reasons: In the first place, the pressure upon the line of fracture causes pain to the patient, and may even bring about a recurrence of the displacement; while, in the second place, it may result in inflammation and possibly ulceration of the skin. Simple fractures have thus become converted into compound ones in the course of a few days.

Splints.—In speaking of splints we shall confine our remarks chiefly to fractures of the extremities. There are certain general rules of treatment applicable to the majority of these fractures.

(*a*) *Any joint acted upon by muscles attached to either of the fragments should be immobilised.* Hence the joint above and below the fracture should be included in the splints; in some fractures, *e.g.* those of the lower end of the humerus, other joints (in this instance those of the wrist and fingers) must be fixed also. Faulty union or non-union is often attributable to neglect of this precaution.

(*b*) *Undue pressure upon any bony prominence over which splints are applied must be avoided,* otherwise there will be much pain, the muscles will be irritated and spasmodically contracted, and sloughs will probably form. The formation of a slough not only leads to further difficulty in applying the splints, but also exposes the patient to the risks of septic absorption. It is still more important that all pressure over the seat of the fracture should be avoided, as otherwise a simple fracture may be converted into a compound one. All splints must be thickly and uniformly padded, so as to minimise the pressure exerted by the hard material of which they are made.

(*c*) *The splints must not be bandaged on too tightly.* An unduly tight bandage not only causes pain, and may give rise to pressure sores over bony prominences, but œdema of the limb below, followed by gangrene or the so-called 'ischæmic paralysis' (see p. 294), may ensue from it.

(*d*) *No bandage should be put on beneath the splint unless it be required to secure a dressing.* In fracture of the upper arm it has been recommended that the limb should be bandaged from the finger tips to the seat of the fracture before the splints are applied, so as to prevent the

occurrence of œdema. We do not advise this. It prevents the surgeon from seeing what is happening when the splints have been applied, and in spite of the bandages œdema may occur, followed by great constriction and even gangrene of the limb. If a bandage be employed, it should not reach higher than the lower end of the splint.

(*e*) *While the splints are being secured to the limb the traction upon the fragments must not be relaxed* nor must the direction of the latter be altered until the splints have been applied. Displacement is otherwise liable to recur.

In selecting any particular form of splint, attention should be paid to the following points: (1) The splint should be as light as is consistent with the work it has to perform; (2) it should permit of evaporation, otherwise decomposition of the sweat may lead to irritation of the skin beneath; (3) it should take its purchase only from bony points, and should not press unduly upon the limb anywhere; (4) it should be easily removable, so as to permit of massage and passive movements of the muscles and neighbouring joints.

The most careful attention must be paid to the padding of splints. In hospitals, splints are generally made ready for use in large numbers by placing cotton wool or tow over the splint and keeping this in place by means of a piece of linen stitched across the back of the splint. Splints so padded are unsuitable because they are made without reference to the shape or peculiarity of the limb to which they are to be applied. The surgeon should pad the splints himself immediately before he puts them on, by arranging tow or wool over the splint, making it thicker where hollows are present. Over this is placed a piece of folded linen which overlaps the splint in all directions; when the splint is to be left on for some time, it is well to place a layer of boric lint between the linen and the skin so as to absorb the sweat and prevent its decomposition. In addition small pads of wool or tow sewn up in muslin should be arranged between the limb and the splint wherever required to avoid pressure upon bony prominences.

In hospital patients powdered fennel, dusted thickly over and among the splints and padding, will be found useful in keeping down vermin which are otherwise liable to infest the retentive apparatus.

Splints may be fastened to the limb by straps or bandages. It is a common custom to fix them on by strips of strapping circularly applied in two or three places, and no doubt this prevents them from slipping. It is only necessary however, when flat wooden splints are employed, and if the limb swells it has the disadvantage that, as the strapping is unyielding, constriction will be caused and the œdema below will be increased. Most splints may be fastened on with bandages, and this is the most comfortable and convenient method. In a few days the original bandages may be removed and fresh ones applied, or a fresh bandage can be put on outside the first, if the latter be getting loose, without disturbing the

fracture in the least. There is not the same risk of œdema of the limb below when bandages alone are used.

When splints are applied to both sides of a limb they may be kept in place by means of three straps of webbing buckled around the top, bottom, and middle of the splints. Strips of bandage tied in slip knots may be used as substitutes; outside them an ordinary bandage may be put on. The outside bandage can be taken off and the fracture inspected without loosening or disturbing the splints; the slip knots can be tightened one at a time without causing any disturbance.

Materials for Splints.—Fixation apparatus may be made of wood,

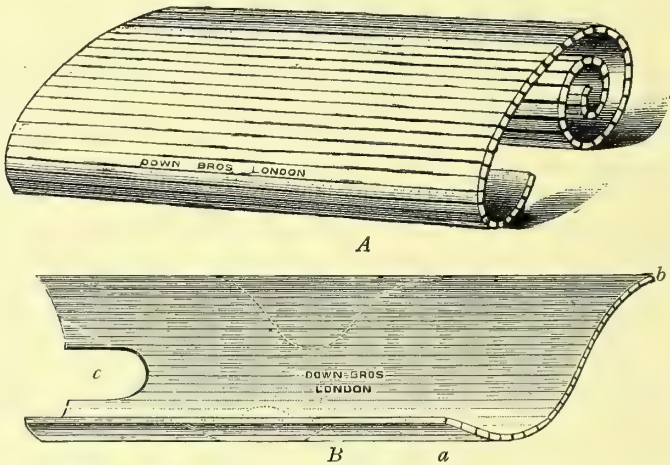


Fig. 112.—Gooch's Splinting. *A.* The roll of splinting before it is cut. The scored surface is uppermost in this figure, the one covered with American cloth being undermost. *B.* The splint cut ready for application to the right lower limb. An aperture (*c*) has been cut for the heel, while the upper end of the splint (*ab*) has been cut obliquely from the inner side (*a*) upwards and outwards to (*b*). The dotted lines indicated upon the splint show the manner in which it is sometimes still further cut away when it is desired to leave the knee exposed.

various kinds of metal, wire, guttapercha, pasteboard, felt, plaster of Paris, silicate of soda, etc.

Wood.—Most wooden splints are made of *deal*, which is strong, light, and cheap. No wooden splint, however, can be made to fit the limb closely, and, therefore, its place often has to be taken by materials which may be made to encircle the limb. To a certain extent this may be done by a wooden splint, if the form known as *Gooch's splint* be employed (see Fig. 112). This is useful when it is required to surround a considerable part of a limb, as in fractures of the upper arm or thigh.

Block tin is very useful for splints, especially after operations and in compound fractures, as it can be sterilised by boiling, cut to any pattern with plaster of Paris shears, moulded so as to fit the limb closely, and incorporated in the dressings. A specially handy material for this latter

purpose is the ordinary **wire netting** used for fences of suitable stoutness, sterilised and moulded to the limb ; it has the great advantage that it does not interfere with the proper absorption of the discharges (see Fig. 113).

Moulded splints are also made from gutta-percha, poroplastic material, and leather. They are very comfortable and may be adjusted rapidly to any particular case. A pattern should first be cut out in brown paper, and upon this the material should be shaped. **Gutta-percha** may be cut with a knife held obliquely or it can be cut with stout scissors after softening in warm water. When cut to pattern, the gutta-percha is immersed in hot water for ten minutes; it is then taken out, laid on a dry towel, with another towel placed over it to remove the excess of moisture, and then the soft gutta-percha is rapidly moulded round the limb and secured

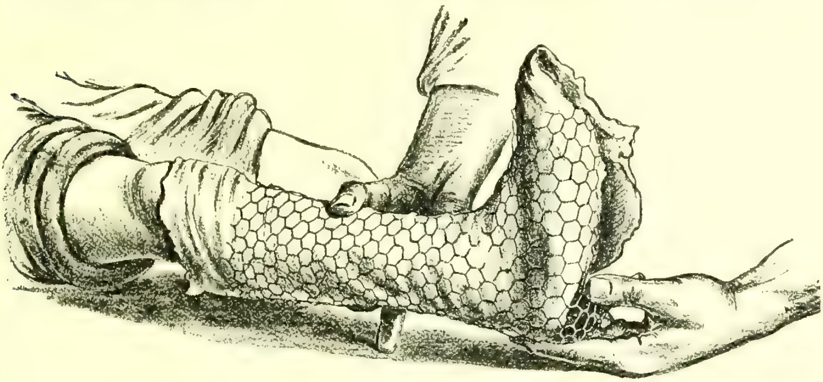


FIG. 113.—WIRE-NETTING SPLINT. The illustration shows the method of incorporating these splints with the dressing. A few layers of gauze are placed directly over the wound, and then a large sheet of the gauze is wrapped around the limb; outside this the wire netting is moulded to the limb, and when this has been done, the gauze is turned down over the free edges of the splint, and more dressing is added over the region of the wound outside the netting. In the figure above, two lateral splints of this netting are being applied.

by a bandage. A dry towel is interposed between the gutta-percha and the limb to prevent scalding. The splint will harden in a few minutes, and it and the temporary padding can then be removed, and the permanent padding arranged so that the splint does not exercise undue pressure anywhere, while it gets a good hold.

Poroplastic material may be cut with a sharp knife if the latter be held at about an angle of 45° ; if the knife be held at right angles it is difficult to cut. The splint, when cut, is softened by holding it before a fierce fire or by putting it in a steam steriliser for a short time. It then sets more slowly than if it had been softened by immersion in hot water, and this gives more time for its careful adaptation to the limb.

Leather can be softened by immersion in vinegar or a solution of acetic acid. Splints of gutta-percha, or of leather, should be perforated with holes, which should be punched from within outwards, in order to allow of the escape of perspiration from beneath.

Plaster of Paris Splints.—A very useful splint applicable to many fractures may be made with plaster of Paris. This may take the form either of an immovable casing completely surrounding the limb and destined to remain on for some time, or of lateral or antero-posterior splints hinged so that either or both can be easily removed to permit of inspection of the limb. The latter form is generally known as Croft's modification of the Bavarian splint, and is of such general utility that we shall describe its application in detail. With slight modification this method may be employed for moulded removable splints in almost any case of fracture.

Croft's Splint.—There are two ways of making this apparatus; in one the splints are lateral, in the other antero-posterior. The former is,

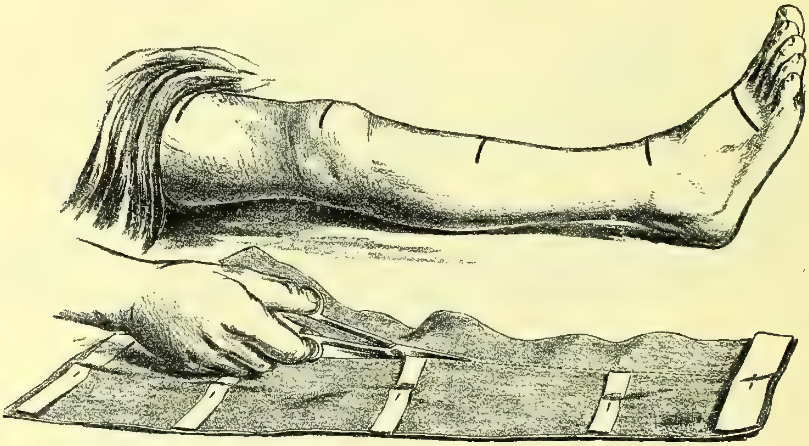


FIG. 114.—CROFT'S SPLINT. *Cutting out the lateral portions.* The pieces of white paper in the lower figure are equal to half the circumference of the limb in the upper figure at the corresponding marks, with the exception of the right-hand one which is equal to the distance from the point of the heel to the mark at the root of the toes.

perhaps, more suitable for fractures of the lower extremities, especially in adults, and is made as follows: A pattern is first cut from a piece of thoroughly shrunk house-flannel. The shaping of this pattern is of considerable importance in the proper application of the splint; a simple but not very accurate method is to take a stocking which fits the patient's sound limb, and lay it flat, with the foot at right angles, upon the house-flannel; from this the pattern is then cut, making due allowance for any swelling that there may be in the region of the fracture. A more accurate way is depicted in (Fig. 114). The distance between the upper limit of the splint and the sole of the foot is first ascertained; then marks are made with ink or an aniline pencil upon the skin in the middle line in front at certain measured distances down the limb. Convenient points are opposite the extreme upper limit of the splint, opposite the centre of

the patella, the centre of the calf, and just above the ankle. The circumference of the limb at each of these points is then ascertained, and strips of bandage or paper are prepared, corresponding in length to half these measurements. A piece of house-flannel, eighteen inches wide, and the length of the intended splint, is then laid upon the table, and the strips of paper or bandage are laid upon the flannel in due order, as ascertained by measurement with a tape, commencing at its upper limit. From these guides the pattern for the lateral splint is then cut out (see Fig. 114). The foot-piece must be exactly at right angles, and must not extend farther forwards than just behind the ball of the great toe. A small slit about two inches long is made at the angle in front of the ankle, and a shorter one over the point of the heel to allow the proper adaptation of the splint to the limb.

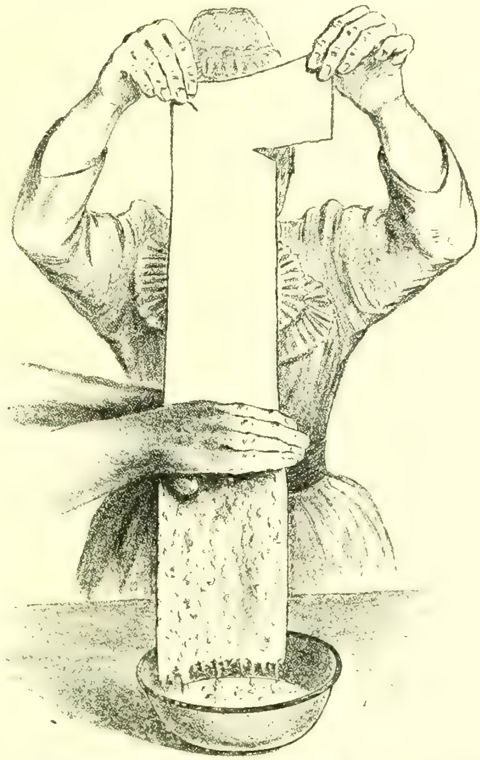


Fig. 115.—Croft's Splint. *Removing the excess of plaster from the lateral portions.* This shows a simple way of ensuring an even distribution of the plaster.

By these means a lateral splint is obtained, which will extend from the middle of the thigh above to the middle of the sole below, and from the middle line of the limb behind to the middle line in front. Three other pieces of house-flannel are then cut to this pattern, and the four pieces are arranged in two superposed pairs, which are laid upon the table in such a manner that the two innermost pieces, namely those that will lie against the skin, are next to the table. A large mackintosh, or several sheets of newspaper, are then placed beneath the affected limb, so as to protect the bedclothes, and the whole extremity is oiled, in order to prevent the splint sticking to the hairs of the limb. The plaster of Paris, which should be of the best quality and free from lumps, is mixed as follows: A sufficiency of cold water is put into a basin, and the plaster is dusted into it by hand. The first plaster dusted in sinks at once, and will continue to do so until the water has become saturated, when the plaster floats upon the surface; this may be taken as an

indication that enough has been added to the water to enable it to solidify into a mass which will not crack and will not set too rapidly. When the saturation point has been reached, and not until then, the plaster should be stirred with the hand until it is of the consistency of thin cream. The outer layer of each lateral splint is immersed in this, and thoroughly impregnated with it. As each piece is impregnated, it is raised from the plaster in the vertical position, and any excess upon its surface removed by passing the hands down it (see Fig. 115). As each layer is prepared, it is laid upon its corresponding unplastered portion which remains on the table.

This finishes the preparation of the splints ; the next step is to bandage them on. Each lateral splint (consisting of the inner unplastered and the outer plastered layer) is raised and applied to its respective side of the limb; and, while this is being done, the surgeon sets the fracture and

FIG. 116.—CROFT'S SPLINT. *Bandaging on the lateral portions.* The surgeon holds the fracture in good position and the foot at right angles, while an assistant keeps the lateral portions in position at their upper end, and a second assistant applies the muslin bandage.

holds the limb in position, taking care to see that the foot is at right angles to the leg. As he does this, he grasps the foot-piece of the two lateral splints, whilst an assistant holds them together at the upper part of the thigh ; a second assistant bandages them rapidly in place (see Fig. 116) with bandages of book-muslin, about two and a half inches wide. They should be steeped in hot water and applied smoothly, evenly, and without any compression. The plaster shrinks slightly as it dries, and, therefore, if the splints were tightly bandaged on there would be a risk of compression as they dry. The bandaging must be done rapidly, as otherwise the plaster sets before it is done, and the splint will not fit smoothly. It is important not to impregnate the flannel with the plaster until everything is ready for the application of the splints, as the plaster is fairly firm by the time the bandaging has been completed. Extension should be maintained until this has occurred.

After the splint has been applied, a hood of cotton-wool is put over the toes, and the limb left exposed upon the bed for some hours to dry.

The rough edges of the splint should be trimmed off before the plaster has set.

If there be no signs of undue pressure upon the limb, such as great pain, lividity, or anæsthesia of the toes, the splint should be left untouched for twenty-four hours ; at the end of this time the interval between the two lateral halves of the splint along the middle line of the front of the leg and the dorsum of the foot, which is merely covered by a few layers of muslin bandage, should be cut down with scissors, and the casing thus converted into two lateral splints hinged together behind by the muslin bandage. The fracture may thus be inspected easily, the limb being held in position in one half of the splint, while the other is turned back

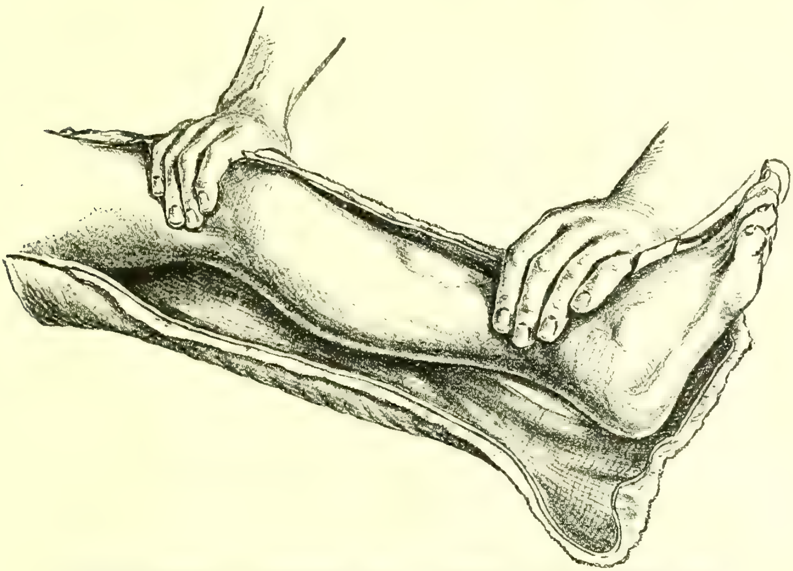


Fig. 117.—Method of Examining a Limb in a Croft's Splint. The limb is held steady in one half of the splint while the other is opened out.

(see Fig. 117). The edges of the splint are then trimmed, and it is re-applied by means of an ordinary bandage. In this condition it may be left until all danger of complications has passed, and then, if desired, it may be converted into an immovable casing by applying a plaster of Paris bandage outside it.

There are several precautions necessary in order to put on this splint successfully. The plaster should be of good quality, known as 'artist's plaster,' and must be free from lumps. It must be kept dry, as moisture combines with the plaster and cannot be driven off by merely drying. In cutting out the splint, allowance should be made for the slight shrinking that occurs when the flannel is impregnated with the plaster. The best plan is to make the lateral pieces large enough to meet in the middle line front and, back so that, when impregnated with the plaster of Paris,

they will shrink sufficiently to leave a slight gap down the middle line in front when they are in contact behind. The lateral halves of the splint should not overlap behind, and they should lie evenly without creases along the side of the limb, so that, when the bandage is applied, they are moulded smoothly to its surface. The bedclothes and carpets or floor of the room should be protected from the plaster by means of mackintoshes, sheets or newspaper, and the surgeon should wear a large apron to protect his own clothes. He will find it well to oil his hands, or to wear cotton gloves before mixing the plaster. Common brown sugar, rubbed well over the hands as they are washed, facilitates the removal of plaster from the hands, but gloves are more satisfactory, as they prevent the roughening of the skin that so often follows the use of plaster.

The splint is a very valuable one, and in many cases has great advantages over any other plan. It is simple, the materials are readily obtainable, it can be applied with extreme rapidity, and, as it takes its purchase from the bony prominences of the limb, to which it fits perfectly, the fracture is absolutely immobilised without undue pressure anywhere ; spasm ceases almost immediately it is applied. It is extremely comfortable, and not only is the sense of cold produced during the drying of the plaster agreeable to the patient, but the slight contraction that takes place tends to restrain the effusion. It is best suited for fractures of the leg ; it is not to be recommended in the thigh owing to the difficulty of getting proper purchase upon the bony prominences of the trunk. It may be used for many compound fractures as well as simple ones, as it is easy to change dressings beneath it, the limb being held firmly in one half of the splint by an assistant, whilst the other half is turned back and the dressing changed. In compound fractures, however, in which large dressings are necessary on account of the amount of discharge, it is perhaps better to employ some other method (see p. 286).

An objection, sometimes urged against this splint, is that, if applied when the limb is much swollen, it is too large when the swelling subsides. This can be met by leaving a larger interval than usual between the edges of the splints in front ; when the swelling subsides, it will only be necessary to bandage the splints more closely together.

Another objection, viz., that there is a risk of gangrene of the limb or sloughing of the parts over the fracture, should there be an increase of effusion beneath the unyielding case, can be obviated by the most ordinary care. The splint should be opened up as described above, directly any symptoms of pressure are manifest. Of these the condition of the toes is the most reliable. Should the toes become livid or should they tingle or be numb, the splint should be opened immediately. If there be great and increasing pain referred to the seat of fracture, the splint should also be opened at once and the pressure relieved. In any case the splint should be cut up at the end of twenty-four hours as a matter of routine, and re-bandaged, after the fracture has been inspected.

The second form of Croft's splint consists of a somewhat trough-shaped posterior splint and a narrow anterior piece; it requires less nicety in application although it has the disadvantage that, composed as it is of an anterior and posterior portion, it is not so suitable for those recent fractures in which it is necessary to have more than the anterior part of the limb easily accessible. It is perhaps most useful for fractures in which a certain amount of consolidation has taken place; it is also useful for fixing the limb in various cases of joint disease. It is made of house-flannel as before, and each anterior and posterior portion consists of two layers, both of which are saturated with plaster. The shape of the two portions of the splint is shown in Fig. 118; no accurate measurements are needed for either. The posterior layer should be wide enough to embrace two-thirds of the circumference of the limb, the anterior a little less than one-third. The two layers of the posterior portion are impregnated with plaster of Paris, mixed as above (see p. 267), held in position along the back of the limb, and secured with a bandage of ordinary muslin or book-muslin. In a fracture undergoing consolidation or in joint disease it is well to put a woollen stocking on the limb to keep the plaster from adhering to the skin. In the case of a recent fracture a layer of boric lint suffices. The two layers of the anterior portion are next impregnated with plaster, applied over the front of the limb outside the bandage securing the posterior portion, fastened on by a second bandage and allowed to dry. This plan is simpler than that of holding both portions in position at the same time, and bandaging them on together (see Fig. 119), but the latter method should be adopted in recent fractures in children, as in them bandaging of the two portions of the splint together involves less disturbance of the limb. The splint is left undisturbed as long as may be desirable; when it is desired to remove it, the muslin bandage is cut up on each side, and the anterior portion of the splint is thus made to form a sort of lid to the trough formed by the posterior portion (see Fig. 120). The superfluous bandage is removed and the splint re-fastened with an ordinary bandage.

FIG. 118.—MODIFIED CROFT'S SPLINT. *Shape of the anterior and posterior portions.* The left-hand one is the narrower anterior piece. The relative width of the two portions can be varied at will to suit the needs of any particular case.

In a muscular or restless patient it may be necessary to strengthen either form of Croft's splint further. This may be done by incorporating with the splint strips of block tin or thin malleable iron bent as may be

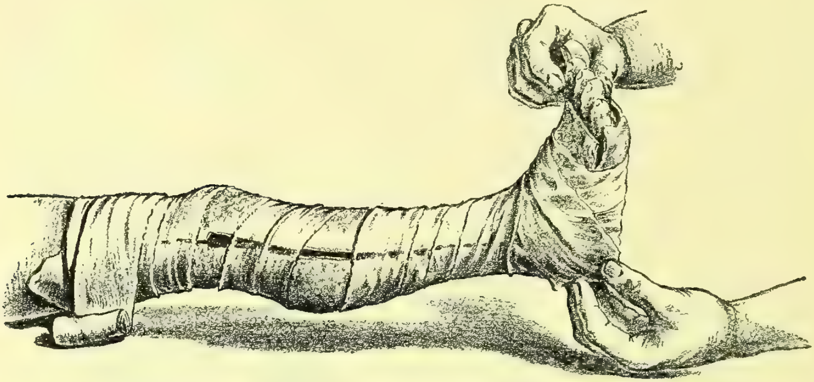


FIG. 119.—MODIFIED CROFT'S SPLINT. *Application of the anterior and posterior portions.* The illustration shows the interval between the two portions down the side of the limb.

required, and applied over the weakest spots. If these are not at hand, an excellent method is to tease out tow into strips, which are dipped in the plaster and applied to the parts that require strengthening; in the case of a splint for the lower extremity this will be about the ankle-joint.

FIG. 120.—MODIFIED CROFT'S SPLINT. *The splint removed.* The figure shows the trough-like splint thus formed.

The Bavarian Splint.—This is a light, comfortable splint, which may be used where much strength is not required. It is made by suspending the limb in a large piece of house-flannel fastened above to a cradle, and then stitching the flannel together over the front of the limb down the middle line of the leg, along the front of the instep and down the middle

of the sole. Plaster of Paris cream is then mixed as directed above, and smeared over the outer surface of the flannel in a layer about half an inch thick (see Fig. 121). Outside this layer of plaster another layer of

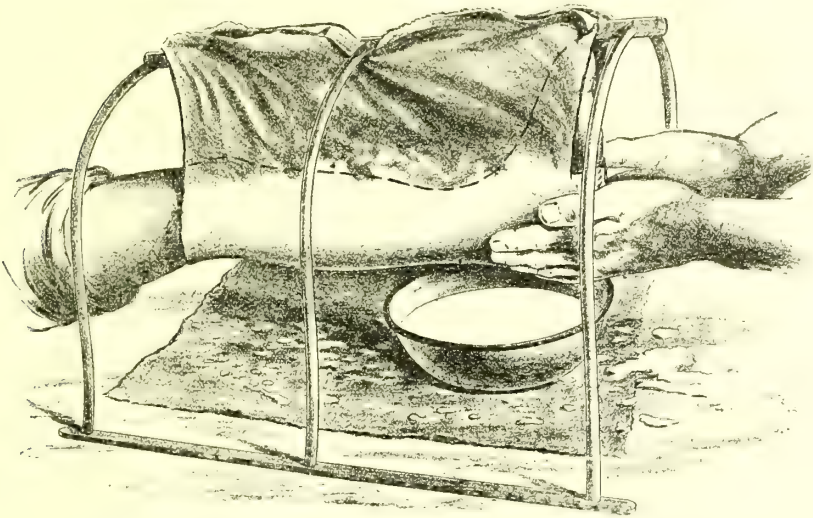


Fig. 121.—Application of a Bavarian Splint. The inner layer of flannel is being smeared with liquid plaster. The outer layer is seen beneath the basin and is ready for application to the plastered surface.

flannel is applied in a manner similar to the first. In this way an accurately moulded splint is formed, consisting of a layer of plaster of Paris enclosed between two layers of flannel. When the plaster has dried, the limb is taken down, the superfluous flannel is cut away, the stitches are removed, and the splint is taken off by bending it open (see Fig. 122); the edges

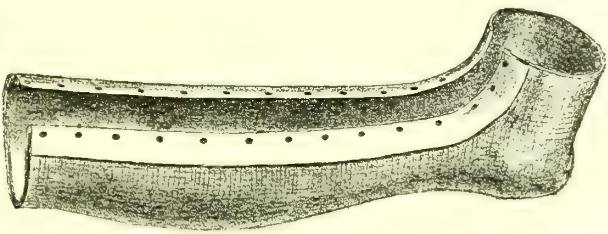


Fig. 122.—Bavarian Splint. The splint has been removed from the limb and finished by binding the edges with leather, and punching eyelet holes in it.

are trimmed up, bound with leather, and punched with eyelet holes, and the splint is re-applied and laced on.

Plaster Casing.—Plaster of Paris is also used as a permanent casing. For this purpose bandages of crinoline muslin are used about four inches wide and impregnated with plaster of Paris. The limb is first enveloped

in a woollen stocking or a bandage of boric lint ; plaster is mixed in a basin as already directed, and the plaster bandages, which should have been immersed previously in enough cold water to cover them, are rapidly applied to the limb, from below upwards, lightly and evenly. During the application of the bandage the surgeon smooths it out from time to time and adds liquid plaster here and there. If necessary, the bandage may be strengthened by means of block tin or tow saturated with plaster (see p. 272).

A permanent casing may be used in a case of fracture from the first; it has the great disadvantage, however, that it takes considerable time to remove, and it is generally necessary to employ either a special form of shears or saw for the purpose. It is best only to use this form of casing for fractures if there is no risk of complications, since cases are known in which swelling has taken place beneath the plaster in recent fractures, and gangrene of the extremity has resulted. Moreover, if a permanent casing be put on a swollen limb, the splint becomes loose when the swelling subsides, and the only remedy for this is to remove the casing and apply a fresh one, a procedure involving considerable disturbance of the fracture. It is, therefore, rarely advisable to make use of this form of splint until consolidation is proceeding satisfactorily. The method of removing these casings by means of Gigli's wire saw is described in Vol. I. p. 399.

The Silicate Bandage.—A lighter material, which is useful in the upper extremity or in children, is the silicate bandage. In employing this, the limb is first enveloped in boric lint, and then bandages of crinoline muslin, soaked in a solution of silicate of potash, are applied outside and left to dry. Three or four thicknesses of bandage usually suffice to ensure a firm, light casing. This splint does not set hard for at least twenty-four hours, and therefore, when it is used, a temporary splint should be fastened to one side of the limb so as to control the fracture until the bandage has set. It has, however, the great advantage of lightness combined with strength and easy applicability.

Extension Apparatus.—When the ends of the bones have not been satisfactorily interlocked, it is often very difficult to prevent overriding of the fragments and recurrence of the deformity when extension is taken off. This is especially the case in fractures of the femur, where the thigh muscles are so powerful that they overcome any fixation apparatus. The fractured ends are deeply seated and cannot be fixed by splints, and moreover, it is extremely difficult to control the movements of the hip joint. In order to obtain a satisfactory result in these cases, therefore, it is necessary either to employ extension, with the object of maintaining the reduction and tiring out the muscles, or to have recourse to operative measures and fasten the broken ends of the bone together. Most surgeons employ some form of extension apparatus in these cases, but the only reliable way of preventing shortening is by operation.

In fractures of the femur, extension may be made either by a weight passing over a pulley, the apparatus being attached to the limb by means of strapping, or by traction applied from the end of a splint

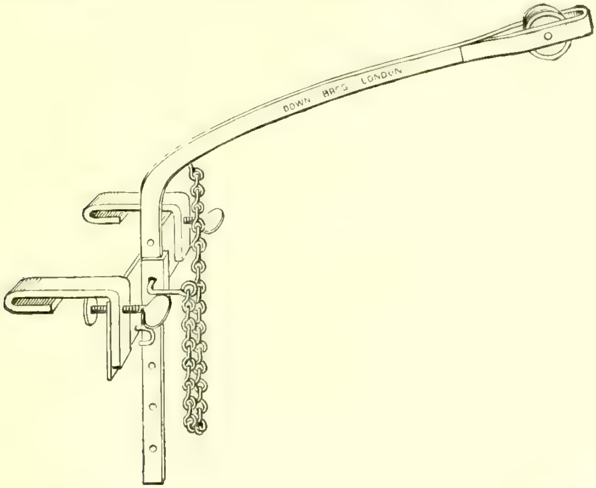


FIG. 123.—PULLEY ARM FOR WEIGHT EXTENSION. The apparatus is fixed to the frame of the bed, and can be raised or lowered at will.

fixed to the limb. In all cases where extension is employed there must be the extending force which pulls the fragment down into position, and also some form of counter-extension to prevent the upper part of the limb and the trunk being displaced.

Weight Extension.—In this form of extension a weight is fastened to

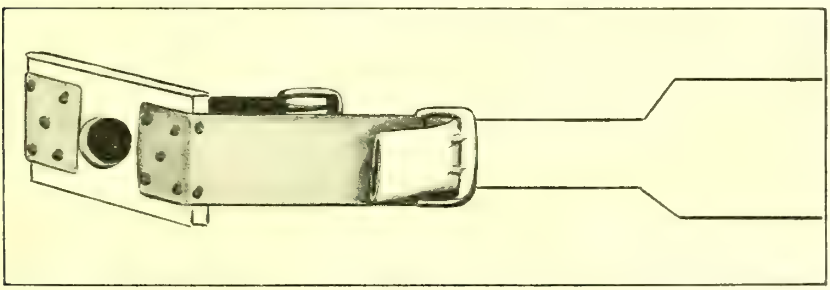


FIG. 124.—STIRRUP FOR USE WITH WEIGHT EXTENSION. On the right is seen the strapping, folded into three as described in the text and attached to the buckle of the wooden 'spreader.'

the end of a cord attached to the limb and passing over a pulley at the foot of the bed (see Fig. 123). The pulley should be arranged so that the cord, by which the extension is made, lies in the long axis of the limb. The method of attaching the weight to the limb, for example, in the case of a fracture of the shaft of the femur is as follows :—

The whole limb is shaved so as to avoid the inconvenience that the adhesion of the strapping to the hairs would entail. A piece of strapping is laid along each side of the limb, about four inches wide for an adult, and long enough to reach from six inches above the fracture to about the same distance beyond the sole. About eighteen inches from the lower end two transverse cuts, each extending about one-third of the way across, are made in the strapping, which is then folded in three with the adhesive side inwards, so as to form a strap which can be attached to the extending weight by buckles (see Fig. 124).

In order to avoid the occurrence of ulceration over the malleoli from the pressure of the strapping, a pad of boric lint should be interposed between the latter and the skin over the base of each malleolus, so that the strapping can pass clear over these prominences without touching them. A bandage is then applied from below upwards to just below the fracture. The free upper ends of the strapping are then turned down,

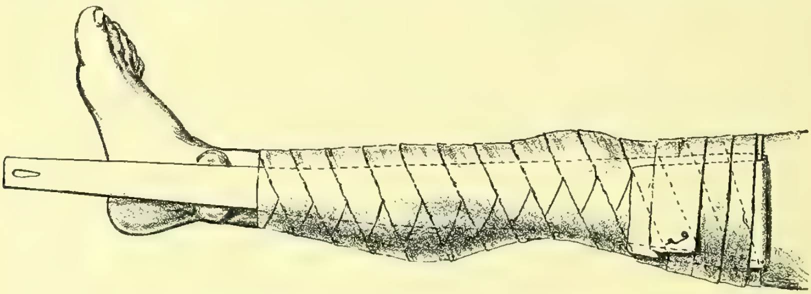


Fig. 125—Stirrup for Weight Extension. The figure shows the lateral pieces of strapping applied to the limb by a bandage, and the manner in which the upper end is turned down and the bandage carried downwards over it. The pad above the malleoli is also shown.

and the bandage is continued downwards over them until they are completely covered (see Fig. 125). Some surgeons fix the lateral pieces by two or three circular strips of strapping applied above the malleoli and just above and below the knee, and then put on a bandage outside this. No doubt this prevents the strapping from slipping more effectually than does the bandage alone, but as the strapping begins to slip, it pulls down the circular bands, which may therefore constrict the limb.

In order to connect the limb with the weight two strips of webbing, six inches long and an inch wide are tacked to a small piece of board, about four inches long by three inches wide, and buckles are sewn to their free ends. The straps made by folding the ends of the strapping are fastened to these buckles. A hole is bored in the centre of the piece of board through which a piece of blind-cord is threaded and is prevented from slipping back by tying a large knot on it. This wooden foot-piece should be at right angles to the axis of the limb, and should not touch the sole. The free end of the cord is passed over the pulley and the

weights are attached to it, the pulley being so arranged that the cord and weights hang clear of the bed. The weight employed will depend upon the muscularity of the limb and the degree of contraction of the muscles ; it usually varies from four to eight pounds. The apparatus should be examined from time to time to see that the strapping does not slip ; it generally requires to be renewed every ten days. It is important to see that the toes do not become pointed ; in order to avoid this, the metatarsal bones should be supported by a sling, the ends of which are pinned to the bandage around the leg, and a cradle should be employed in order to keep off the pressure of the bed-clothes. Further, it is important to see that no outward rotation of the limb occurs unless in so far as that may be necessary to bring the two fragments into accurate

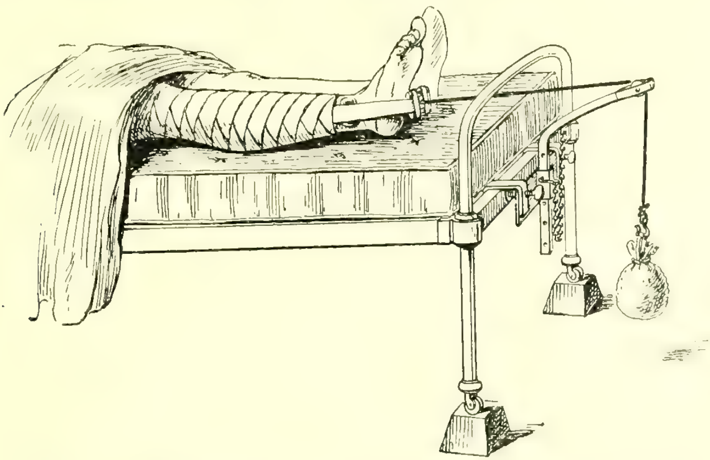


Fig. 126.—Weight Extension applied to the Lower Limb. The limb, with the stirrup applied as shown in Fig. 125, is extended by means of a cord passing over the pulley shown in Fig. 123. The foot of the bed is raised on blocks to provide counter-extension. The toes should be kept elevated by means of a sling passed beneath them, and having the ends pinned to the strapping around the leg, as described in the text.

adjustment. This can be prevented by a sandbag along each side of the limb.

Counter-extension may be exerted by raising the foot of the bed on blocks, so that the trunk tends to slide down towards the head of the bed (see Fig. 126). In the case of adults in whom considerable weight is employed, well-fitting spats are often more useful than strapping. They should extend well up the leg and, if necessary, should be padded so that no undue pressure falls upon the dorsum of the foot. Straps are sewn to the lower edges and are attached to the stirrup (see p. 276) by buckles.

Vertical Extension.—Vertical extension of the limb is a very useful method of treating fractures of the femur in young children. The stirrup is applied as before and the cord fastened to it is secured to a bag

or similar structure vertically over the affected hip joint. The limb is drawn up into the vertical position, the buttocks being lifted just clear of the bed. The sound limb should also be tied up to the bar so that the child cannot relax the extension upon the fracture by putting the sound limb upon the bed and raising himself upon it. This method is referred to in detail on p. 386.

Splint Extension.—In other cases the traction may be made from one end of a fixed splint. This has the advantage over simple weight extension that it steadies the limb and can be made to prevent rotation. An example of this method is seen in the case of Liston's long splint; in this splint, however, the counter-extension is apt to cause irritation and ulceration about the perineum. Hessing's splint is now more generally employed as it permits the patient to walk about. It is fully described and illustrated on p. 375. It is a very useful form of splint as well as a very comfortable one, but it is expensive and therefore not within the means of the ordinary hospital patient. Bryant's 'double splint,' figured on p. 387, is much used in hospital practice for children.

For all cases of extension the bed should be so arranged that it is impossible for the trunk to sink down into the mattress, as otherwise the fragments will be displaced and the resistance which the extension has to overcome will be increased. To prevent this, 'fracture boards,' which are stout planks about a foot broad and as long as the bed is wide, are placed transversely upon the frame of the bed immediately beneath a firm and thick mattress. If necessary, a water-pillow should be placed beneath the pelvis. A cradle should be placed over the affected limb to obviate the friction of the bedclothes and the risk of pointing of the toes from their pressure. A single blanket over the limb will keep it warm, while the cradle supports the rest of the bedclothes.

Mechanical Fixation of the Fractured Ends.—While the methods above described are satisfactory in many cases, they sometimes fail, and something further must be done. It may happen that, notwithstanding the greatest care and ingenuity, true bony union may fail, or if it occurs there may be so much shortening and deformity as to interfere seriously with the usefulness of the limb. Formerly the danger of compound fractures was so great that both surgeon and patient contented themselves with the best results they could obtain without operation, but at the present time it is not considered justifiable to leave the patient with an ununited or a badly united fracture, or even a recent fracture in bad position, if the fragments can be maintained in proper position by means of an operation. Hence operative interference is being employed in a large and increasing number of fractures. This is more especially the case in fractures accompanied by wide separation of the fragments, as, for example, those of the patella or the olecranon, and those in which the line of fracture is oblique and the fragments over-ride considerably, —as is so frequently the case in fractures in the shaft of the femur—

and those accompanied by so much deformity that a really good result cannot be obtained otherwise. Operative measures are particularly necessary in fractures about joints—notably the elbow—where the displacement interferes with movement, and where satisfactory re-position and retention of the fragments cannot be obtained by simple manipulation and the application of splints.

When operation is called for, it should be undertaken as soon as possible after the accident; if it be delayed, the most favourable time will have passed and it will be difficult to rectify the displacement. When the fragments are separated, as in old fractures of the patella, the muscles become shortened, and it is extremely difficult to get the fragments together again unless the muscle be partially divided. At the same time the fragments become so thinned and atrophied that they do not offer a good hold for the wires. If operation be delayed in oblique fractures with much overlapping or displacement, the muscles, fasciæ, and other soft tissues become contracted, and a dense fibrous mass surrounds the fracture so that the ends cannot be separated and cleared, and it becomes very difficult to bring the fragments into position and to exert enough traction to overcome the shortening. And lastly, if operation be delayed in fractures into joints—for example, the elbow—it will be almost impossible to obtain a good result without chipping away portions of the articular surfaces or even excising the joint. All these difficulties can be avoided if operative interference be carried out soon after the fracture has occurred and before any consolidation has taken place—in fact, as soon as the surgeon sees that he cannot obtain a good result in any other way.

While in most cases—as, for example, those in which there is separation of the fragments—there will be no hesitation in operating at once; in others—as in oblique fractures—the surgeon may be tempted to wait. In the latter cases the decision can be greatly facilitated by radiography, and all oblique fractures should be examined under the X-rays within three days of the accident; this can be done without removing the splints. If the position be bad, operative measures can be undertaken before consolidation has taken place. It is always advisable to take a stereoscopic radiogram if the apparatus be at hand, as thereby the surgeon is enabled to see at once the exact relative position of the fractured ends, and he can therefore judge clearly in what direction it is most advisable to approach the fracture.

In these operations strict asepsis of the wound is absolutely essential; without it operation would be unjustifiable. The operative procedure consists in cutting down upon the fracture, clearing away all the blood-clot between and around the ends of the bone, removing any tissues interposed between the fractured ends, and then bringing the latter into apposition. As a rule, it is not sufficient merely to get the broken ends into position, and means must be taken to fix them together until consolidation has occurred by means of metal plates, screws, or

tacks, or by steel pins introduced temporarily and removed later (see p. 305).

When there is separation of the fragments—such as in fractures of the olecranon or the patella—it is sufficient to approximate the fragments by means of a wire (see Chaps. XVII. and XX.). In fractures of the shaft of a long bone, however, particularly oblique ones, wiring is not the best method as it does not prevent movement between the ends; moreover, the wire may cut through the bone, and shortening may recur a few days later. Hence, in oblique fractures and those in the neighbourhood of joints, or where it is necessary to fix a small piece, the fragments should be screwed or nailed together (see p. 305).

PREVENTION OF ADHESIONS IN JOINTS AND MUSCLES.

The best methods of preventing adhesions and promoting the nutrition of the parts may be considered under two heads—(*a*) the after-treatment in cases where splints are chiefly relied upon, and (*b*) the after-treatment in cases where massage is chiefly employed.

When Splints are employed.—Two important points must be considered—namely, how long should absolute rest of the part be maintained, and how long should the use of splints be continued. The length of time required for bony union to occur varies considerably, but usually displacement is not likely to recur in the upper arm after the lapse of four weeks, and in the leg after about six weeks, and many surgeons retain the splints for this length of time. After the splints are left off, a considerable time often elapses before the patient regains the full use of the limb, partly because the muscles have shrunk from disuse and partly because of the hæmorrhage into them, while at the points where the muscles and other soft tissues pass over the fracture adhesions are apt to occur which are difficult to get rid of. This is especially marked in fractures in the immediate vicinity of joints. In these cases, if the part be kept at rest during the whole time required for bony union, temporary stiffness of the joint at least is certain to occur; and, unless vigorous measures be taken, permanent stiffness will ensue, notwithstanding that the fracture may have united in good position. Hence the tendency now is to shorten the length of time during which splints are kept on, as far as is compatible with safety, or at any rate to take measures during the course of the treatment to prevent the occurrence of these adhesions. We shall indicate immediately the various steps of the procedure we are accustomed to employ to attain this end.

When Massage is mainly relied upon.—Among French surgeons it is becoming a common practice to treat a case of fracture by massage from the first, to the almost entire exclusion of the use of splints. In some cases splints are practically not employed at all, whilst in most they are merely put on as a restraining apparatus in the intervals between

the massage, the limb being quite free of them during that process. The object of the massage is to secure absorption of the effused blood and inflammatory products, to ensure free movement of the neighbouring joints, tendons, and muscles, and to prevent the occurrence of adhesions or to break down any that may have formed; the slight movement necessarily imparted to the fractured ends during the process is not prejudicial to union of the fracture.

While we are not prepared to discard splints entirely, we think that massage and careful passive movement may be associated with them to a far greater extent than has been the case heretofore, not only without risk to the union, but with actual advantage to the patient; in this way it is comparatively easy to get the limb into such a condition that the patient is able to commence using it freely as soon as the broken bone has united sufficiently firmly to bear the weight of the body. This, as everyone knows, is rarely the case when fractures are treated by splints alone for a long period. When the splints are discarded, the limb is generally much crippled, both by œdema, which is often extensive and recurs every time the limb is in the dependent position for any length of time, and also by adhesion of the torn muscles to the tissues near the seat of the fracture; when the fracture is near an articular end, there are not uncommonly considerable adhesions in the neighbouring joint. For example, in Pott's or Colles's fracture, the chief difficulty is not in setting the fracture, but in restoring to the patient a useful limb; the after-treatment often has to be carried out for months with the greatest assiduity.

It is claimed, and, we think correctly, that, by using massage early and repeatedly, dispensing with splints and employing passive movement as soon as possible, union takes place as readily as when splints alone are employed; and that, moreover, when union has occurred there are no complications such as stiff joints, or adherent muscles, or tendons to be treated. This method requires more attention, occupies more time, and calls for more skill than the ordinary method of reducing the fracture, putting it up in position, and maintaining the splints in place until satisfactory union has occurred; moreover, it is not applicable to every case. The cases best suited for it are simple fractures, free from ordinary complications, which are easily reduced and maintained in position by simple splinting or retentive apparatus. We shall therefore describe more in detail the steps of the treatment, which is best carried out by the surgeon himself.

When putting up the limb it is well to choose a form of splint in which the strapping or bandages can be applied so as to leave the neighbourhood of the seat of fracture freely exposed. Simple rubbing of the limb with the palm of the hand in an upward direction for about ten minutes at a time once daily should be begun from the first, and is often very soothing; after the first few days it may be done twice daily, each sitting

being slightly increased in length. It is also well to flex and extend the toes in fractures of the leg, or the fingers in fractures of the forearm, at least once a day. This can be done without disturbing the fracture. The rubbing causes rapid diminution of the pain and swelling, and by the end of the first week it will be possible to remove the bandages from the extremity of the limb, so as to leave the ankle and foot, or the wrist and the fingers, free. At this stage passive movements of the joints above and below the fracture should be performed daily. The seat of fracture should be carefully steadied by one hand, whilst the joint is moved with the other. It is only necessary to perform each movement of which the joint is capable once at each sitting ; there is often some pain at first, but this soon subsides. This should be carried out until the fourteenth day after the injury, and during this time the limb is not taken off the splint.

The next step is to lift the limb carefully off the splint and lay it upon a firm flat pillow. The rubbing can now be carried out more vigorously than before, and may be repeated in sittings of twenty-five minutes each twice a day. When the fracture is about three weeks old, fair union will have taken place between the fractured ends, and a light splint, preferably of poroplastic, which does not fix the joint below, may be substituted for the more rigid apparatus. If the fracture be in the lower extremity, the patient may get about on crutches with a patten on the sound foot or in a Hessing's splint ; he should be encouraged to move the ankle, although no weight must be borne upon it. Massage and passive movements should be persevered with until consolidation has advanced sufficiently to allow the weight to be borne upon the limb. The patient will then regain practically complete use of the limb without loss of time.

It is scarcely necessary to say that this form of treatment requires to be carried out with the greatest care, and by a trained masseur if the surgeon be unable to do it himself. In the cases for which it is specially valuable, namely, fractures in the vicinity of joints, such as Pott's fracture, Colles's fracture, or fractures in the vicinity of the elbow-joint, the treatment is difficult to carry out satisfactorily, and demands great care in preventing undue mobility of the fragments during the passive movements of the joints.

This method, which is the one we are accustomed to employ, seems to us to strike a mean between the somewhat rash disregard of the use of splints, advocated by some of the French surgeons, on the one hand, and the undoubtedly unsatisfactory results of their prolonged use on the other.

THE TREATMENT OF COMPOUND FRACTURES.

In compound fractures the first and absolutely essential point is to secure asepsis of the wound. In former days compound fractures were amongst the most dangerous of injuries, and it was in connection with their treatment that Lister began his antiseptic work. Unless the wound be rendered aseptic, it becomes the seat of septic inflammatory troubles, and, the medulla of the bone being exposed, grave results frequently arise. The septic inflammation does not remain limited to the soft parts, but may spread to the medulla and extend upwards as a septic osteo-myelitis, which may lead to a fatal pyæmia ; or, if the patient survive after a prolonged and dangerous illness, necrosis of the bone results and amputation may become necessary. Indeed, so dangerous was compound fracture in former times that many surgeons looked on amputation as the best routine practice in the great majority of instances, even when there was no injury to vessels, nerves, etc. We now know that wounds exposing a bone or its medulla, if aseptic, are not more serious than wounds of the soft parts, and therefore there is no reason for amputation on account of the fractured bone alone, provided that the wound can be rendered aseptic. In compound fractures, however, the wound has not been inflicted by the surgeon and is therefore usually soiled, and the problem is, not to prevent the entrance of micro-organisms, but to destroy those that have already gained admission ; it will of necessity happen that in a certain, fortunately small, number of cases, the attempt to render the wound aseptic fails.

THE TREATMENT OF A COMPOUND FRACTURE IN WHICH THE WOUND IN THE SOFT PARTS IS CONSIDERABLE.

Treatment of the Wound.—We have already referred to this (see Vol. I. p. 163) in considering the treatment of wounds inflicted accidentally, but it may be well to recapitulate it here. An anæsthetic should be administered and a tourniquet applied to the limb well above the seat of fracture. The skin for a considerable area around the wound is then washed with ether soap and strong mixture, shaved, and again washed with ether soap and strong mixture and scrubbed with a nail brush, the wound being kept covered while the surrounding skin is being disinfected. The edges of the skin around the opening which leads to the fracture should be cut away ; they are certain to be soiled and contused, and, therefore, rapid healing is not likely to occur.

The wound should be enlarged as much as may be necessary to obtain thorough access to the injured parts. There need be no hesitation in making a very large incision if necessary, in order to see the condition of the deeper parts. All blood-clot should be sponged out, all foreign matter removed, and any contused tissue clipped away. The whole wound should be then scrubbed out thoroughly with strong mixture.

Treatment of the Fractured Ends.—The ends of the bone should next be examined, and, if they are very dirty, a thin layer should be sawn or gouged off the surface ; any loose pieces should be removed. The whole of the wound, except the incisions made by the surgeon, should be carefully sponged with undiluted carbolic acid, which must not be allowed to run over the edges of the skin ; the fractured ends should receive similar treatment. There is no need to apprehend danger from using undiluted carbolic acid in this manner, and we are at a loss to explain the cases of carbolic gangrene which are reported, especially from America, where it is said to follow the use of even a 1 per cent. solution. We have never found the application of the undiluted acid to a wound lead to necrosis of anything more than microscopic portions of tissue, nor have we had any difficulty in obtaining prompt and sound healing of the wounds so treated. Certainly we emphatically deny that it causes suppuration. On the other hand, we have found it a thoroughly satisfactory antiseptic in these cases, and it must not be forgotten that the initial triumphs of antiseptic surgery were obtained by Lord Lister, when using pure carbolic acid in the treatment of compound fractures.

After the wound and all its recesses have been purified, the tourniquet is removed and any bleeding points are tied. The tourniquet is employed in these cases to arrest the oozing which, if allowed to go on, would wash off the pure carbolic acid as soon as it was applied, and would therefore interfere with its germicidal action.

The position of the fractured ends of the bones should next be ascertained ; in the great majority of cases it will be advisable to fix them together by some mechanical means (see p. 305). When, however, there is no tendency to recurrence of the displacement after accurate coaptation has been secured, mechanical fixation is not necessarily called for. The greater part of the wound may then be stitched up, but a large drainage tube should be inserted at the most dependent part and, if necessary, a counter-opening should be made lest the attempt to purify the wound should have failed. Antiseptic dressings are applied, and it is well to use a sterilised splint of perforated block tin or wire netting (see p. 265) moulded to the part and incorporated with the dressings. Another splint of wood or metal may be applied outside the dressings if additional security be desired ; the limb should then be put in the position best calculated to obtain relaxation of the muscles.

THE TREATMENT OF A COMPOUND FRACTURE IN WHICH THE WOUND IS SMALL.

When the wound is small the surgeon is frequently tempted simply to disinfect the skin, possibly syringe out the wound, and apply an antiseptic dressing. No doubt these measures suffice in some cases, particularly when the wound has been caused by the protrusion of a sharp bony fragment which has receded immediately afterwards ; it is most likely to be effectual in parts not covered by clothes. At the same time it

is impossible to be certain of obtaining a good result, and it is better to enlarge even a very small wound sufficiently to enable the whole of the interior and the ends of the bones to be effectively disinfected. The wound made by the surgeon can be stitched up again, and no delay in healing will take place. However, should the surgeon yield to the temptation simply to disinfect the skin and syringe out the wound, some care must be taken in carrying out the method. It is necessary to see that the lotion—preferably 1 in 20 carbolic—comes into contact with and washes away the clots from the ends of the bones, is able to escape freely, and is not driven along the planes of cellular tissue. It is well to attach a rubber catheter to the syringe, to introduce its point through the wound, and by inserting it in various directions, especially deep down in the neighbourhood of the bones, to see that the lotion comes into contact with all the parts. The lotion should not be driven forcibly into the wound, and if the latter be small it will be necessary to enlarge it, in order to allow of the free escape of the fluid. A good plan to ensure that the fluid is not driven into the tissues under pressure, is to use for the purposes of the irrigation a catheter, connected with a glass funnel by a few inches of india-rubber tubing.

AFTER-TREATMENT OF COMPOUND FRACTURES. —*If the attempt at securing asepsis be successful,* the course of events will be the same as after ordinary operations on bone. If blood comes through the dressing during the first twenty-four hours, the bandage and the outer layers of wool should be soaked with 1 in 20 carbolic lotion, and a fresh dressing applied outside. The wound should be dressed in four days and the drainage tube removed. The limb is put up again with the wire splint incorporated in the dressings and, in many cases, need not be disturbed for several weeks.

Should the attempt to obtain asepsis fail, the case must be treated as a septic wound. If a high temperature and signs of osteo-myelitis supervene, the question of amputation will arise, and this will probably prove the safest practice when the patient is getting progressively worse, more especially when there are rigors. The amputation will be performed through or above the joint next above the fracture.

It is generally found, however, that, even should the case become septic after the thorough treatment just described, the free drainage provided renders extensive infection of the medulla rare, and the limb may still be saved. Under these circumstances it is a question whether the plates or wires employed to fix the bones together should be removed. This question is decided by ascertaining whether they cause much irritation ; should there be very little, they may be left *in situ* for some weeks, because they tend to steady the bones, but if irritation is caused they must be removed.

In these septic cases frequent changes of dressings are necessary, and as the parts must be disturbed as little as possible during the dressing lest non-union should result, special precautions are necessary. It is not

sufficient to trust to an assistant to steady the limb. When two lateral splints are used, it may be possible to keep the parts steady by removing one splint, while the assistant holds the limb firmly against the other ; the dressing is applied to the side thus exposed and the splint is re-applied ; then the opposite splint is removed, the limb is firmly held in contact with the one first removed, and the change of dressing is completed (see Fig. 117). This plan is difficult when the wound is extensive, and under these circumstances the following arrangement will be found more satisfactory. Two or three rods of malleable iron are taken and are bent outwards into a semicircle over the region of the wound as shown in

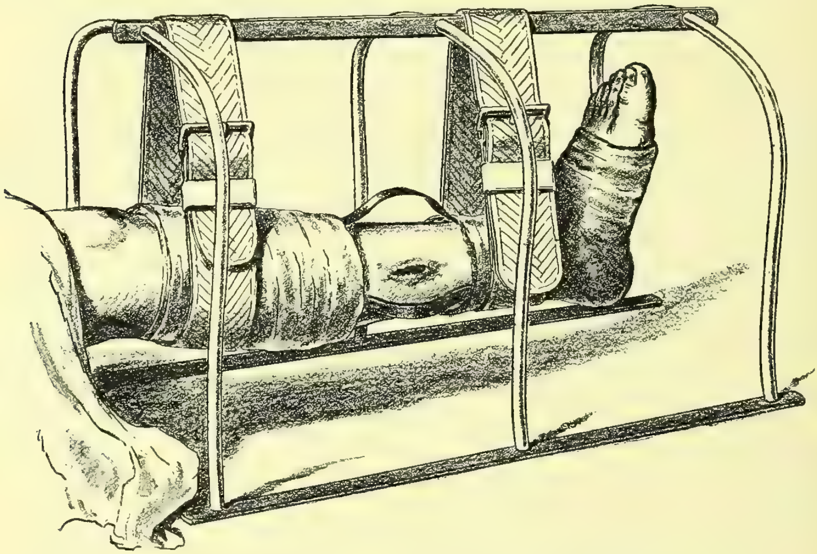


FIG. 127.—INTERRUPTED PLASTER OF PARIS SPLINT. Showing how the iron bars incorporated with the plaster bandage are bent to allow free access to the wound. The limb is slung from a cradle ; as a rule the plaster bandage would be carried above the knee.

Fig. 127. The extremities of these bars are then incorporated in a plaster of Paris bandage. A bandage of boric lint is first applied to the limb above and below the wound ; over this a few turns of plaster of Paris bandage are put on, and then the metal bars are adjusted, and their ends are covered in by fresh turns of the plaster bandage. An interruption is thus formed of sufficient size to allow of free access to the wound. In this way a firm splint, taking its purchase from the limb above and below the wound, is formed, the whole area is accessible, and dressings can be renewed as frequently as may be necessary without disturbing the fracture. The edges of the plaster must not come too near the wound, otherwise they will be soiled by the discharges.

Necrosis of the fractured ends often occurs in septic cases, and after a

time the necrosed portions will become loose and should be removed. The time required for this detachment varies from about six weeks in the case of the forearm to about six months in the case of the femur. Non-union is liable to follow necrosis of this kind and, therefore, the interrupted splint just described should be dispensed with as soon as the wound has healed, and the limb put up in a Croft's splint, daily massage, without disturbance of the ends of the bones, being employed to keep up the nutrition of the ends of the bones.

THE TREATMENT OF COMPOUND FRACTURES IN WHICH THE DAMAGE IS EXTREME.

Although the methods just described apply to the majority of compound fractures met with in practice, cases, nevertheless, will arise in which the question of *amputation* has to be decided first of all. When a limb has been partially or completely torn off, there will be no hesitation in deciding that the stump must be trimmed or the partially torn-off limb must be amputated. Similarly, when, in addition to extensive comminution of the bones, there is laceration of the main vessels, nerves, and muscles, amputation will be the better practice ; and immediate amputation may be required in badly lacerated wounds, such as machinery accidents, in which the bone is much broken and the soft parts are badly lacerated and soiled with greasy dirt. Again, in old persons or in those much enfeebled by constitutional disease, the most satisfactory plan of bringing cases of bad compound fracture to a successful termination, especially when the bone is comminuted, is a primary amputation. But except for these cases, an attempt should always be made to save the limb whenever the surgeon feels that, by disinfection of the wound and the establishment of drainage, he will probably be able to obviate the occurrence of septic infection. The mere rupture of the main vessels or nerves of the limb in addition to a compound fracture does not necessarily call for primary amputation. When the vessels are divided, the case should be watched to see whether gangrene occurs, and amputation can be performed within the first twenty-four or forty-eight hours if it be found inevitable. When the nerves are ruptured they should be sutured in the manner recommended for injuries of nerves (see p. 117) immediately after the wound has been disinfected.

Union is often delayed in compound fractures, and it is not uncommon to find that the fragments still move upon one another after six or eight weeks. Indeed it may almost be said that this is the rule rather than the exception, and that something like three or four months are necessary to obtain satisfactory union in the majority of compound fractures. It is somewhat difficult to understand why this should be, but probably it is due to the absence of the external callus, which plays a considerable part in the repair of simple fractures.

TREATMENT OF COMPLICATED FRACTURES.

The complications incidental to fractures may be divided into—(1) Those that occur at the time of the injury and are due directly to it, and (2) those that occur during the subsequent progress of the case.

THE TREATMENT OF IMMEDIATE COMPLICATIONS.

The following are the chief complications occurring at the time of the accident: (*a*) The skin may be divided or torn in the vicinity of the fracture without, however, any communication with the fracture itself being established; (*b*) injury to the main artery of the limb; (*c*) injury to the main vein; (*d*) injury to the nerves; (*e*) injury to a neighbouring viscus; (*f*) injuries to joints; (*g*) dislocation complicating the fracture; (*h*) fatty embolism.

Wounds of the Skin not communicating with the Fracture.—The treatment of a complication of this kind is simply that of a wound of the soft parts; the skin and the wound must be disinfected and the appropriate treatment for a lacerated wound must be adopted (see Vol. I. p. 171).

Injury to the Main Artery of the Limb.—In some cases the main artery of the limb may be torn and profuse hæmorrhage may occur into the tissues. If the vessel be large and the tissues lax, the patient may actually bleed to death. Failing this, a large blood swelling occurs, accompanied by loss of the pulse in the limb below and coldness and numbness of the extremity. In other cases the artery may be occluded by the pressure exerted upon it by one of the displaced fragments; or again, it may be punctured by a spicule of bone, with the result that hæmorrhage occurs from the aperture, and a false or traumatic aneurysm ensues.

The treatment of these injuries is dealt with under injuries of the arteries (see Vol. I. p. 106). It is important to cut down upon and secure the divided ends of a torn vessel as soon as possible; delay only renders the operation more difficult owing to the infiltration of the tissues with blood and lymph, and if the bleeding be allowed to continue, the interference with the circulation in the limb below the fracture will increase and may lead to gangrene from pressure upon the collateral circulation, should the patient not die of the hæmorrhage.

As soon, therefore, as the diagnosis has been made, the skin should be disinfected and the circulation controlled by Esmarch's elastic tourniquet. A free incision is then made over the line of the vessel, the clots are turned out and the ends of the artery exposed and tied. If the cavity formed by the extravasated blood be large, it is well to insert a drainage tube for the first few days.

The treatment of the fracture itself will follow the lines already

indicated. If the fracture be oblique, or if there be any difficulty in keeping the ends in position, it is well to take advantage of the incision already made and to fix the fragments together. After the wound has been stitched up, a drainage tube is inserted at one end, and the limb is put on a splint, the lower end of which should be slightly elevated.

When the circulation is interrupted by the pressure exerted upon the vessel by a displaced fragment—an accident which is indicated by loss of pulsation and by coldness of the limb below without the occurrence of any swelling at the seat of fracture—it is possible that the pressure will be removed and the circulation re-established on effecting accurate coaptation of the fractured ends.

If this cannot be done by simple manipulation, or if there be any uncertainty as to the accuracy of the reposition of the fragments, the best practice is to make an incision at once and fix the fragments in place (see p. 305). At the same time the limb below should be disinfected, wrapped up in antiseptic wool, as for the treatment of impending gangrene (see Vol. I. p. 73), and carefully watched to see whether or not the circulation becomes re-established. In putting the limb on a splint under these circumstances, it is important that no undue pressure should be exercised on any part, as otherwise sloughing readily occurs at any point where even slight pressure has been exerted, although the collateral circulation may be restored in the limb as a whole. Should gangrene occur, immediate amputation should be resorted to, as soon as its extent can be gauged. As a rule it is well to amputate at, or just above the seat of fracture.

False Aneurysm.—The treatment of a false aneurysm has been already described (see p. 167). The aneurysm need not be operated upon until the fracture has undergone consolidation, unless it be increasing rapidly, for it does not necessarily interfere with union, whilst the operation required for its cure might possibly do so.

Injury to the Main Vein.—Injuries to the main vein, occurring as complications of fracture, do not materially aggravate the severity of the case. Repair and recovery usually take place uninterruptedly ; all that is necessary is to facilitate the return of blood from the parts below by raising the limb slightly above the level of the trunk ; at the same time the limb should be enveloped in antiseptic wool, so as to promote warmth. When both the main artery and vein are damaged simultaneously, the danger of gangrene is greater than when the injury is limited to only one of these vessels, but recovery will occur in a good many cases, if care be taken to wrap the limb up, to elevate it, and to see that there is no undue pressure anywhere.

Injury to the Main Nerve.—The main nerves are sometimes torn by the fractured ends, and this accident is evidenced by loss of sensation and motion in the part supplied by the nerves injured. When it is clear that an accident of this kind has happened, the nerve ends

should be sutured without loss of time (see p. 117). It must be remembered, however, that it is not always easy to be quite certain that loss of sensation in a case of simple fracture is due to actual rupture of the nerve and not to bruising or compression ; if any doubt exists, it is well to set the fracture first and then to wait for a week or two, to see whether recovery will take place. If at the end of this time no improvement occurs, it is probable that the nerve has been divided, and it should be exposed at the seat of fracture without further delay. If the nerve is intact, no harm is done; whereas, if it has been torn, delay will only diminish the chances of a satisfactory issue. If the nerve be so much bruised and injured that there must evidently be a considerable amount of scar tissue formed, the most satisfactory practice is to excise the damaged part and suture the ends.

In putting up the fracture, pressure by the splint or other restraining apparatus must be studiously avoided, because imperfectly innervated parts are more prone to slough from pressure than are healthy tissues.

Injury to a Neighbouring Viscus.—The treatment of a complication of this kind will be the treatment appropriate to the injury of the viscus affected, rather than anything specially directed to the fracture. The viscera which are most commonly injured are the lungs in fractures of the true ribs, the kidneys and spleen in fractures of the lower ribs, and the bladder and rectum in fractures of the pelvis. It is sufficient to mention here that these injuries to neighbouring viscera occur ; their appropriate treatment is dealt with in connection with injuries of the particular organs.

Wounds of Joints.—When a fracture is in close proximity to a joint, the articulation may be injured. In simple fractures this may occur from the fracture extending into the joint ; fractures of the patella or the olecranon necessarily implicate the joint, and this is also the case in fractures of the articular ends of bones, such as the condyles of the femur or the humerus.

The difficulties that occur in these cases—putting aside fractures of the patella and the olecranon, which will be referred to in detail—are not so much in promoting repair, as in preventing the occurrence of deformity and limitation of movement, which almost invariably result when these fractures are put up on splints in the ordinary manner. This is due to the fact that it is very difficult, on the one hand, to get the fragments into proper position, and, on the other hand, to maintain them there when once they have been properly reduced. A very slight irregularity of the articular surface may lead to marked impairment of the movements of the joint ; indeed, in many cases the resulting limb is so stiff and useless that the surgeon has subsequently to interfere and possibly to excise the joint. Hence when it is evident, on a careful examination of a fracture into a joint, under an anæsthetic and with the help of the X-ray screen, that the fragments will not remain in apposition

after reduction, it is best to cut down upon the fractured ends immediately and fix them in position. Operation has the further advantage that the bones are thereby firmly fixed, and thus the surgeon can commence passive movements much earlier than would otherwise be feasible. This prevents the occurrence of adhesions, which, apart from the displacement of the bony surfaces, is a very common cause of the subsequent disability of the limb.

Fractures may also be complicated by an injury to the joint in other ways; thus, a lacerated wound of the soft parts may extend into the joint, although the fracture itself does not. These cases must be treated as a wound of a joint, the fracture being put up in the ordinary manner. When, however, there is a wound of the joint complicating a fracture extending into it, the broken ends of the bones should be fastened together when the joint is cleaned out. In these cases free drainage must be provided, because there is always a risk that the cleansing of the joint may not have been effectual.

Dislocation complicating Fracture.—When the fracture is not situated in the immediate vicinity of the dislocated joint, the treatment is to reduce the dislocation and then to set the fracture and employ suitable retentive apparatus. Passive movement must be begun early; if the limb be kept at rest until the fracture has united, hopeless stillness of the joint may have resulted. Movement can be practised without risk to the union of the fracture, as the limb can be enveloped in a moulded splint and moved as a whole.

When, however, the fracture is in the immediate vicinity of the dislocated joint, the case is much more difficult to deal with. A good example of this is seen in dislocation of the shoulder combined with fracture of the neck of the humerus. Under these circumstances it is difficult to reduce the dislocation, for it is impossible to get a good hold on the head of the bone. The old rule was to put up the fracture with the long fragment in a line with the short one—*i.e.* the dislocated head—and, after the fracture had united, to attempt reduction of the dislocation. If this attempt were unsuccessful, as was usually the case, excision was sometimes resorted to, in order to get a useful limb.

It is now generally recognised, however, that the best treatment is to cut down upon the head of the bone, at the time of the injury, replace it in position, sew up the rent in the capsule, and then fix the ends of the bones together, so as to enable passive movement to be commenced early, and thus avoid the stiffness which is apt to follow even a perfectly aseptic operation unless the joint be moved quite early.

Fat-embolism.—In severely comminuted fractures fat may enter the veins and be carried on in the circulation. This occurs to some extent in all fractures, but no bad effects result unless a large quantity of fat gains access to the circulation in this manner. When, however, large quantities pass into the veins, the fat globules may become impacted in

the smaller vessels of the lungs, the brain, or the kidneys, and may give rise to serious symptoms.

The symptoms of fat-embolism following a simple fracture generally come on within a few hours of the injury, and naturally vary according to the seat of the embolism. When the emboli are lodged *in the lungs* infarcts form, and are followed by œdema of the lungs and patches of pneumonia. In very rare cases the emboli may be sufficiently numerous to kill the patient in a few minutes. The symptoms are sometimes difficult to distinguish from those of shock, but as a rule they do not come on for some hours after the injury, whereas the onset of shock is generally coincident with the accident. The first symptoms are severe dyspnœa, accompanied by pain in the chest, cyanosis, and cough, with frothy blood-stained expectoration. If the patient recover from this, pneumonia develops.

When the emboli occur *in the brain*, the symptoms are delirium, followed by coma. The pulse is small, rapid, and irregular, and the coma may gradually deepen until death ensues; in some cases, however, the coma slowly passes off and recovery takes place.

The symptoms are rarely severe when the emboli are *in the kidneys*; there may be strangury and hæmaturia, but usually the emboli manifest themselves only by large quantities of oil in the urine.

The first thing obviously is to prevent the further entrance of fat into the circulation. With this object the fracture must be reduced immediately and completely immobilised. When the patient is restless or inclined to be delirious, a Croft's splint (see p. 266) is the best apparatus.

In the treatment of the embolism itself nothing specific can be done; all that is possible is to treat symptoms as they arise. Stimulants are indicated, and are best given by the mouth; in the more severe cases, subcutaneous injections of ether or brandy may be required.

When the emboli are in the lungs, it is useful to cup the sides and back of the chest (see Vol. I. p. 7); later on, the application of a mustard leaf or mustard poultices (see Vol. I. p. 19) will help to relieve the dyspnœa. The patient should be kept warm and have plenty of fresh air. Inhalations of oxygen should be employed if there be much cyanosis.

THE TREATMENT OF THE COMPLICATIONS OCCURRING DURING THE PROGRESS OF A FRACTURE.

The chief complications that may occur during the treatment of a fracture are: (1) Œdema, pruritus and the formation of vesicles; (2) phlebitis and thrombosis; (3) gangrene; (4) ischæmic paralysis; (5) septic complications, such as suppuration, erysipelas, cellulitis, tetanus, etc.; (6) œdema of the lungs and hypostatic pneumonia; (7) delirium tremens; (8) bed-sores; (9) necrosis; (10) mal-union; (11) non-union;

(12) inclusion of nerves in the callus ; (13) adhesion of muscles or tendons to the fractured ends ; and (14) swelling of the limb, on using it after union of the fracture.

Œdema, Pruritus, and Vesication.—The occurrence of œdema and the formation of vesicles over the region of the fracture are commonest when the injury is due to direct violence, and when there has been much extravasation of blood. These conditions are predisposed to by undue mobility of the fractured ends and by undue pressure exerted by splints or bandages.

Immediate reduction of the fracture and immobilisation of the limb in a slightly elevated position to favour the return of blood are essential. If there be much tension of the skin and a tendency to vesication, the splint should be arranged so that the affected part is accessible, and evaporating lotions, such as spirit or lead and opium lotion (see Vol. I. p. 9), should be applied. An ice-bag is often used, but great care must be taken in employing it on account of the depressing effect of the cold upon the already damaged soft parts, which may become gangrenous, and thus a simple fracture may be converted into a compound one. If used at all, it should only be in vigorous healthy subjects ; lint should be interposed between the skin and the ice-bag, and the condition of the parts frequently inspected.

If the itching be troublesome, the skin should be dusted over with boric acid in powder (either alone or with an equal quantity of starch) and the vesicles should be pricked as they form and the fluid let out ; the epithelial covering of the vesicles should not be removed. If the skin over the area of the fracture becomes eczematous, diachylon or dilute boric ointment, or a dusting powder consisting of equal parts of oxide of zinc and boric acid may be applied.

Sometimes the tension is so great as to threaten gangrene of the skin ; this is shown by increasing duskiness, coldness, and anæsthesia of the part. Gangrene may sometimes be avoided if free incisions be made through the skin into the subcutaneous tissues, so as to let out the blood and the inflammatory effusion and thus to relieve the tension. If incisions be made in this way, they will probably convert a simple fracture into a compound one, and great care must therefore be taken to secure asepsis. The subsequent treatment will be that of compound fracture.

Thrombosis.—This is a rare complication, and is often unavoidable. It may occur either at the time of the accident from injury to the veins, or may ensue later as a result of phlebitis. As a rule it is of little importance ; at most it leads to some œdema of the limb below the seat of fracture. In rare cases, however, it may extend into the larger veins and interfere with the circulation, or portions of clot may be detached and give rise to emboli elsewhere.

The limb should be raised so as to favour the return of blood, tight bandages above the seat of fracture should be avoided, and the patient

should be kept perfectly quiet so as to avoid the risk of detachment of portions of the clot. The patient should be confined to the horizontal position for a fortnight after the spread of the thrombus has ceased.

Gangrene.—This complication may occur from damage to the main vessels at the time of the injury, or it may result later from the injudicious application of splints or bandages. Some patients are particularly insensitive to pain, and, if they have any, look upon it as a necessary consequence of the injury. Many cases have occurred where, after a fracture has been put up apparently satisfactorily, œdema and gangrene have occurred subsequently without the patient complaining of pain until too late to obviate the mischief.

The gangrene will be of the moist variety and its treatment is detailed elsewhere (see Vol. I. Chap. IV.). When the circulation is evidently imperfect, the limb should be disinfected immediately after the occurrence of the injury, a large dressing applied, and the limb raised on pillows. If, in spite of this, it be evident that gangrene will occur, amputation should be performed at, or above the seat of injury to the vessels, which will be at the seat of fracture. There is no object in waiting, for in the course of two or three days it will be clear whether recovery will result.

Volkmann's Contracture or 'Ischæmic Paralysis.'—Volkmann was the first to describe a contracted condition of the flexors of the hand and wrist, supervening not uncommonly after fractures of the radius and ulna or the lower end of the humerus. He gave it the name of 'ischæmic paralysis,' on the assumption that the condition was due to death of the muscle elements consequent upon prolonged deprivation of blood as the result of splint pressure. It is not certain, however, that this is really the cause of the affection, and, therefore, it is perhaps better to term it 'Volkmann's contracture,' until we know more about its pathology.

Etiology.—The condition is certainly most often met with in connection with fractures of the forearm, but it is not confined to this region. It is frequently associated with undue pressure from tight splints or bandages, and there are often pressure sores on the front and outer aspects of the forearm; sometimes there is also definite pressure paralysis of the nerves of the forearm, such as the median, ulnar, or posterior interosseous. Cases are recorded, however, in which this condition of contracture has followed severe contusion of the muscles of the forearm without any fracture or external wound, in which no splints have been used and in which no sores or bullæ have developed during the course of the case. The great majority of cases occur in the forearm, but we have seen at least two cases in the lower extremity, following the use of a tight plaster casing for suspected joint disease. It is unlikely that pure 'ischæmia' or privation of blood-supply to the muscles can produce the affection unaided, and the condition is probably due to a myositis set up by the injury or the splint pressure, or by both combined. A similar condition

also follows prolonged suppuration in or around muscles, and is also said to occur as a sequel to prolonged exposure to cold.

Symptoms.—In the early stages there is swelling and lividity of the extremity often, but not invariably, accompanied by pain. The extremity is cold and œdematous, particularly when allowed to hang down. Later on, pressure sores or a number of large bullæ often develop under the splint, but not invariably so. The typical lesions are paralysis of the

FIG. 128.—VOLKMANN'S CONTRACTURE. The upper figure shows the wrist extended; the fingers are then automatically flexed. In the lower figure the wrist is flexed; the finger can then be extended.

flexor muscles followed by contracture, which sets in early and progresses rapidly. The electrical reaction of the muscles affected is unaltered in recent uncomplicated cases. If there be any reaction of degeneration present there is some nerve lesion coexisting, probably due to direct pressure by the splint on one of the nerve trunks. In uncomplicated cases also there is no anæsthesia, and no trophic skin lesions; the whole extremity may be œdematous and livid, but there are no cutaneous eruptions or ulcerations. When the forearm is affected, the hand begins to

assume a characteristic position almost from the first. The fingers become flexed into the palm, and cannot be extended even by the use of considerable force as long as the wrist is kept extended. As soon, however, as flexion of the wrist is practised the fingers are extended at the metacarpophalangeal joints, and at the interphalangeal joints, but in severe cases these latter joints remain flexed. As the affection progresses, the wrist joint becomes flexed, and the nails are forced into the palm. The forearm is pronated and the elbow is somewhat flexed. The flexor muscles become so much wasted that they cannot be felt. All the joints remain normal. In the case of a growing child the bones of the affected forearm do not develop as rapidly as those on the unaffected side.

Diagnosis.—As a rule this is easy if it be borne in mind that the paralysis and the contracture occur practically simultaneously, and that the contracture affects the damaged muscles. In cases of paralysis due to nerve pressure the contraction comes on much later, and affects the healthy muscles that oppose the action of the paralysed ones. Another point of great importance in the diagnosis is that there is no reaction of degeneration in cases of Volkmann's contracture. The electrical reactions are normal, while in paralysis from nerve pressure the reaction of degeneration sets in early.

Prognosis.—When the affection was first described it was thought that no treatment was of any avail. Experience shows that this is by no means the case, and numerous recoveries have followed the painstaking use of appropriate treatment. The final result, however, would seem to be influenced by the amount of damage done to the muscles when the case comes under notice. If the muscles are so disorganised that they are practically non-existent, little can be hoped for from treatment, but much may be done when the damage is only partial, and in these cases good functional results have been reported.

Treatment.—Treatment may be non-operative or operative, and each has its own particular place. The more important is the *non-operative treatment,* which aims at restoring the functions of the damaged muscles, and which is said to suffice alone if it be begun sufficiently early; in any case, operation is only undertaken as an adjunct to non-operative measures. The most valuable method is to employ massage to the muscles of the forearm, combined with the use of passive movements, in the form of extension of the wrist and finger-joints, supination of the forearm, and extension of the elbow. This treatment should be carried out twice daily for a quarter of an hour at a time from the time the case is first seen, and must be persevered with, probably, for two years or more, but it need not be done by a skilled masseur. Galvanism may also possibly be of help, but is undoubtedly not essential. As the case improves, the patient should perform muscular exercises designed to strengthen the muscles in fault.

Should the contracture be extreme when the case is first seen, or

should it become so in spite of treatment, it may be necessary to undertake *operative measures* designed to relieve the tension of the contracted muscles, as it is well known that muscles that are unduly stretched recover their functions slowly, if at all. The usual operation—which, however, is often disappointing—is lengthening the flexor tendons in the forearm. The actual method of performing the lengthening of the tendons is fully described in Chap. IX., and need not be repeated here. We prefer to do it through an H-shaped incision, the vertical limbs being at the junction of the anterior with the lateral aspects of the forearm, and the transverse one about an inch above the crease of the wrist. By this means two flaps are raised and thrown upwards and downwards to expose the flexor tendons ; if preferred, a flap may be raised with its convexity downwards. As there are many tendons to lengthen in this operation, and it is most important to join each proximal to its corresponding distal end, and as all the tendons must be cut before the fingers can be extended, and as it is therefore impossible to suture each tendon as soon as it is lengthened, we have adopted the following plan to avoid confusion : After each tendon has been raised from its bed and divided in the manner determined upon, a long silk suture is passed through each cut end well above and well below the line of section. The two ends of this suture are knotted together so that the ends of the tendon are connected by a long loop which does not interfere with the rest of the operation, while the corresponding ends of the tendon can be found at once by traction upon its loop when it is desired to put in the permanent sutures. The division of the tendons must be practised as high up the forearm as practicable, so as to get the slight protuberance formed by the unions out of the way of the annular ligament. It is well, if possible, to divide different tendons on slightly different levels. The method of lengthening will depend upon the amount of shortening present ; the ⅂-method is, perhaps, the most useful.

After the operation the hand is put up with the fingers and wrist slightly flexed, and massage and gentle passive movements are employed as soon as union has occurred. It is important that this operation should not be done until the contracture has reached its maximum, and it should not therefore be undertaken until at least three months have elapsed since the occurrence of the injury.

Another method of treatment for this condition is to resect a portion of the radius and ulna with a view of shortening these bones sufficiently to enable the fingers and the wrist to be brought into the fully extended position. The section of the bones should be oblique, and the divided ends are fastened together after the requisite amount of bone has been removed. Several cases have been treated in this manner, but unfortunately the operation has been followed more than once by non-union of the bones. If it is done, the division of the two bones should be made at different levels.

Septic Complications.—These are more likely to follow a compound than a simple fracture, but they may occur in simple fractures complicated by injuries of the skin, even when the latter are mere abrasions. When they do occur, they naturally complicate the case seriously, because the dressings must be changed repeatedly, and this entails much disturbance of the limb. Hence it is of great importance to examine the skin for abrasions in all cases of fracture, and, if any be found, to disinfect them and apply an antiseptic dressing before the limb is put up in a retentive apparatus. The treatment of these complications is dealt with fully in Vol. I. p. 155.

Œdema of the Lungs and Hypostatic Pneumonia.—Congestion of the bases of the lungs, ending in a low form of pneumonia, is a troublesome and dangerous complication in old people who are the subjects of a fracture of the lower extremity which confines them to bed in the horizontal position ; it occurs most commonly after fractures of the neck of the femur.

Œdema of the lung in old people confined to bed by a fracture is due to defective expansion of the bases of the lungs ; it usually commences about the end of the first fortnight after the receipt of the injury. If not treated immediately, it is apt to spread rapidly and bring about a fatal result, the bronchial tubes becoming choked with mucus, and the patient dying practically of asphyxia.

Apart from this, pneumonia may also be caused by direct injury to the lung in cases of fractured ribs ; but this form is usually slight, limited and transient, and a fatal result seldom occurs from it except when the chest wall has been so extensively injured that respiration is seriously impeded. Pneumonia may also occur after fractures high up in the dorsal spine, and is then a frequent cause of death. It is due partly to the faulty expansion of the lung from paralysis of the intercostals, and partly also to some trophic influence upon the nutrition of the lung itself. Its onset is often very rapid, and it soon ends fatally.

Treatment.—The great danger of pneumonia after fractures of the lower extremity in old people should be borne in mind and hence, before any signs of congestion of the lungs occur, the patient should be placed in such a position that the lungs may expand as freely as possible. The chest should be enveloped in cotton wool, and nourishing food and stimulants administered. Splints, if employed, should be so arranged that the patient may be propped up in bed almost in the sitting position ; in fractures of the neck of the femur usually all that can be done in the first instance is to employ light extension, as any really efficient splint would prevent the patient being propped up. If the patient be simply raised on pillows he will slip down in the bed, and in a short time become almost horizontal ; hence a foot-rest should be fixed opposite the sound limb. If the patient's means permit, a Hessing's splint should be procured as soon as possible. This must be specially made for each patient

so that a week or ten days will elapse before it can be applied. During this time the measures just described should be carried out. The details of the splint are given on p. 374.

If symptoms of pneumonia arise, it is well to surround the bed with a curtain or tent, and to place a steam-kettle beside it, so that the patient shall breathe moist air. A tent can be improvised by means of screens roofed in by a sheet. Diffusible stimulants, such as ammonia combined with expectorants, should be given,[1] and brandy may be administered in doses of half an ounce every three hours or oftener as necessity arises.

If the lung trouble increases, a large jacket poultice of linseed meal renewed every three or four hours should be substituted for the cotton wool, and when there is much cyanosis, oxygen inhalations (see Vol. I. p. 177) should be employed. When, however, the affection reaches this advanced stage the chances of recovery are very slight. It is very important to get all these old people up as soon as possible, as they may be attacked by this complication at any time ; in speaking of fractures of the neck of the femur we shall refer to forms of apparatus that may be employed with this object.

Delirium Tremens.—This is a common complication of fractures in heavy drinkers. The attack often comes on within a few hours of the receipt of the injury, and at first manifests itself by restlessness, loquacity and disinclination to remain in bed. This is followed by the well-known hallucinations of vision and muscular tremors. It is noticeable that the patient constantly tries to move the fractured limb, and apparently these attempts do not cause pain. A serious risk of this constant disturbance of the fracture is fatty embolism (see p. 291). Non-union is also prone to occur, and, of course, a simple fracture may readily be made compound. As a rule the affection subsides spontaneously in three or four days. In elderly people, however, who are the subjects of habitual intemperance and in whom the kidneys are diseased, the condition gets steadily worse until the patient falls into a comatose, typhoid state, and dies.

An essential point in the treatment is to immobilise the limb as soon as possible, and for this purpose there is nothing so efficacious as a Croft's splint, applied as soon as the fracture is seen or as soon as the first symptoms of delirium tremens set in. It is usually necessary to administer an anæsthetic to keep the parts at rest until the plaster has set. The limb can then be fastened to the bed, and the patient restrained by an attendant.

The medical treatment consists essentially in supporting the strength by nutritious food, and in trying to induce sleep. The patient should be isolated and kept in a dark room ; a strong attendant should be present

[1] The following prescription may be used with advantage: ℞—Ammon. carbonatis, gr. v. ; Spirit. ætheris, ʒss ; Vini ipecac., ♏x. ; Tinct. scillæ, ♏xv. ; Aq. menth. pip., ad ℥j. Misce. Ft. mist. Every four hours.

to restrain his attempts to get out of bed. Narcotics should be given, and probably the best are chloral in doses of 25 grains by mouth or double that quantity by the rectum, bromide of potassium in doses of 30–60 grains and paraldehyde in drachm doses repeated if necessary every three hours until they take effect. As a rule, morphine should be avoided; in some cases, however, in persons who are extremely restless, who do not respond to the use of chloral and in whom the kidneys are healthy, opium given by mouth may be extremely beneficial. Hyoscine hydrobromide given hypodermically in doses of $\frac{1}{200}$th to $\frac{1}{100}$th of a grain is also a very powerful sedative which may succeed when the others fail.

The patient should take as much nourishing food as possible; this should be concentrated and highly nutritious, beef-juice, strong soups, milk, egg and brandy, and underdone meat being administered by the mouth, or by means of the stomach tube. To allay the intense craving for stimulants, it is sometimes well to spice the food with cayenne or other condiments. When the pulse is feeble, rapid, and compressible, an ounce of brandy may be given every three or four hours; some physicians recommend an ounce of port wine every hour.

Bed-sores.—In many fractures, particularly in elderly people, the prevention of bed-sores is of the highest importance. Their prophylaxis and treatment have been already dealt with (see Vol. I. p. 70).

Necrosis.—This is a common complication of septic compound fractures; it results from the occurrence of periostitis and osteo-myelitis, and its treatment is dealt with on p. 444.

Mal-union.—By mal-union is meant union of a fracture with the fragments in faulty position. There may be shortening from either overlapping or from angular deformity. In most cases mal-union does not give rise to any serious disability, but in some the limb may be crippled; this is most likely to be the case if the mal-union has occurred in the neighbourhood of a joint, when the movements of the latter may be severely restricted.

Causes.—Mal-union may be due to (1) imperfect reduction and coaptation of the fracture, in the first instance; (2) subsequent occurrence of deformity, owing to imperfect apparatus or to the occurrence of muscular spasm although the fracture was put up in good position at first; (3) yielding of the callus formed during consolidation of the fracture, the result of too early removal of the splints (in which case the patient bears weight upon the limb before it is strong enough), or of some constitutional condition which prevents the formation of sufficiently firm bone.

Treatment.—It is obvious that mal-union is preventible in the majority of cases. When it impairs the usefulness of the limb, an attempt must be made to rectify it. An angular deformity, detected before consolidation is complete, can generally be remedied by splints properly adjusted along the concavity of the limb, combined with elastic pressure exerted over

the seat of fracture. Care must be taken not to employ too great pressure, as otherwise ulceration will occur beneath the elastic bandage. When the union is fairly firm, it is best to administer an anæsthetic and to straighten the limb forcibly, after which the limb is put up in plaster of Paris. Forcible bending of the bone under an anæsthetic is usually necessary if more than a month has elapsed since the fracture ; before that, elastic pressure will probably suffice.

When consolidation has occurred with angular deformity, the bone must be re-fractured before it can be got into position ; this usually requires a cutting operation. When the fracture is situated about the centre of the shaft of the bone in adults, it may be possible to re-fracture the bone by means of a powerful instrument such as Butcher's osteoclast. This method, however, is uncertain; it may cause serious bruising of the soft parts, the fracture it produces may be comminuted, and, in children, the epiphysis may separate before the union gives way, especially if the fracture be near the articular end. Hence, when the union is strong enough to resist re-fracture by means of the hands alone, the fracture should be cut down upon and the union divided with a chisel or saw. In an oblique fracture with one end overlapping the other, an operation of this kind is essential if a good result is to be obtained.

Definite rules for operations of this nature cannot be formulated, because everything depends upon the nature of the deformity and the bone affected; but the following points should be borne in mind as they apply to all operations of this kind.

These operations try the surgeon's power of keeping the wound aseptic as much as any operations in surgery. The prolonged handling and bruising of important and deep-seated structures that are unavoidable during the manipulation of the fractured ends, give rise to a wound that is prone to become septic unless the most rigid asepsis prevails. Should sepsis supervene, the results are apt to be very disastrous.

Division of the bone should be effected with as little disturbance of the parts as possible ; it is best effected with a chisel and hammer if possible. It is important to ascertain the nature of the line of fracture by means of the X-rays before operation, in order that the incision may be so planned as to approach and divide the union with the least possible damage to the soft parts.

Free incisions should always be made, so that the surgeon can see exactly what he is doing, and is not hampered by want of room.

In oblique fractures the great difficulty is the shrinking of the soft parts, and after the fracture has been divided, it will be necessary to exert powerful extension, either by the help of an assistant or by means of pulleys, and to divide cautiously all tight bands which interfere with the proper reduction of the fracture, taking care, of course, not to divide important structures, such as large vessels or nerves.

In all oblique fractures, and in every case in which there is the least

difficulty in keeping the bone ends in proper apposition, mechanical means of fixation (see p. 305) must be resorted to.

The wound should be sutured without a drainage tube if possible, but when there has been severe laceration of the tissues and the oozing is persistent, a tube should be used. When the deep fascia is thick and well defined, as, for example, in the thigh, this should be sutured separately so as to prevent adhesion of the muscles to the skin, and to check hæmorrhage from the muscle; it obviates the risk of a collection of blood, which would call for the use of a drainage tube (see Fig. 129).

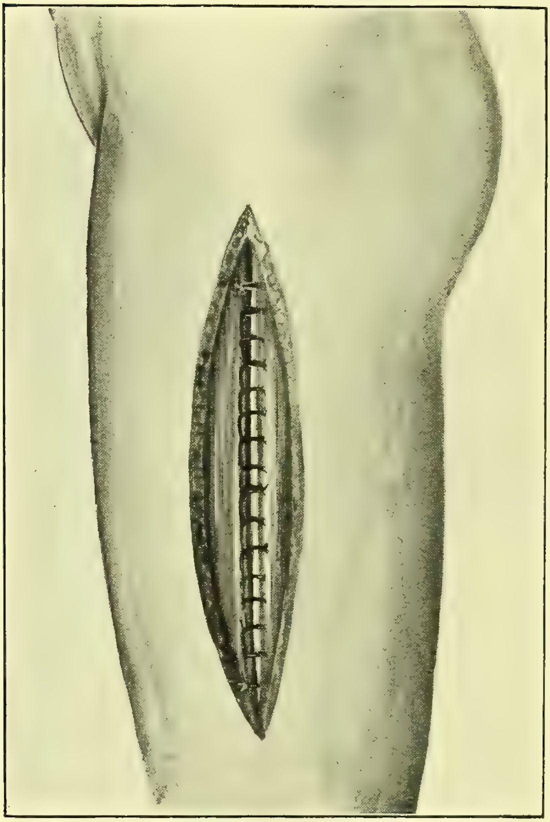


Fig. 129.—Suture of the Deep Fascia after Operations for uniting the Femur. The deep fascia is united by a continuous 'blanket suture' and thus bulging of the large thigh muscles is prevented.

The limb should be left undisturbed for ten days unless a drainage tube has been used, when it must be dressed at the end of twenty-four to forty-eight hours and the tube removed. The stitches are removed at the end of ten days, and the splints re-applied. The wound should be sufficiently firmly healed for massage to be started at the end of the third week. The splints may be removed temporarily for the massage without any risk, if this be done carefully.

Ossification in the union may be delayed after these operations, and the splints, therefore, should not be finally abandoned until the surgeon is sure that bony union has taken place. After union is complete, massage should be persevered with, in order to increase the nutrition of the muscles and to loosen adhesions between them and the bone.

Non-union.—Proper consolidation between the broken ends of the

bone does not always take place ; the term non-union is applied to a large group of cases, in some of which the union is imperfect, while in others no attempt at repair has taken place.

Pathological Changes.—The following conditions are the most common :

(1) The union may be simply delayed ; little or no union may be present at the end of six or eight weeks, but the fracture gradually consolidates as times goes on. This is really delayed union, and it is chiefly important as a reminder that want of union, at the end of two or three months, does not necessarily imply the establishment of an ununited fracture.

(2) The callus which forms after the accident may be normal in amount and of the usual structure, but it may remain soft, and ossification may not occur.

(3) The callus may become converted into fibrous tissue, so that the union consists of fibrous or ligamentous material which varies in extent and in strength according to the position of the fracture and the condition of the patient.

(4) An actual false joint may form between the ends of the bone which become bound together by a strong fibrous capsule enclosing a cavity into which the broken ends project ; this cavity may contain synovial fluid.

(5) No attempt at union may occur, the ends of the bone becoming thin, pointed, and atrophied.

Causes.—The causes of non-union are variable, and may be divided into local conditions interfering with union, and general constitutional states of the patient.

Local.—The local causes may be classified as follows: (1) The presence between the ends of the bones, of muscle, fibrous tissue or tendon, or even a piece of loose bone, as in comminuted fractures. (2) Imperfect immobilisation of the limb during repair. (3) Undue separation of the fractured surfaces, either from overlapping or from retraction, as in fracture of the patella. (4) Imperfect blood-supply to the lower fragment when the fracture is situated near the nutrient artery of the bone. A good example of this is seen when there are two fractures in a long bone, the upper of which involves the nutrient artery. The upper fracture will probably unite satisfactorily, the lower may not. (5) Extensive necrosis in compound fractures.

Constitutional.—Among the constitutional causes of non-union may be mentioned: (1) Specific fevers occurring during the progress of the case ; these are especially apt to lead to non-union if they commence about the time of the injury. (2) Alcoholism, apart from the occurrence of delirium tremens and the resulting disturbance of the fracture, may retard union after fracture especially when there are degenerative changes in the kidneys. (3) In rickets there is often abundant callus thrown out, but normal ossification does not take place and the seat of fracture remains yielding. Scurvy, gout, anaemia, general debility, old age, and paralysis,

are described as causes of this complication, but their influence is problematical.

Treatment.—It is first of all necessary to be certain that the case is one of non-union and not one in which union is merely delayed. As we have already pointed out, union is sometimes very slow. Hence, when there is no evident cause for the occurrence of non-union, such as a piece of muscle between the ends of the bone or separation of the fragments, a fracture should not be considered an ununited one until at least six months have elapsed, and during that time the limb should be put up in an apparatus, such as a silicate or plaster of Paris casing renewed from time to time. The patient may get about upon crutches, or may be wheeled about in a bath-chair, provided that this does not interfere with the immobility of the fracture. Massage of the limb is useful, provided that undue disturbance of the seat of fracture be avoided. Thyroid extract, in doses cautiously increased from 5 grains daily, is highly spoken of by some authorities. Recently passive hyperæmia by Bier's method (see Vol. I.) has been used with advantage.

The treatment of a fracture that is definitely ununited may be both local and general.

General.—The general treatment embraces an easily digestible diet, and good hygiene; appropriate medical measures must be taken against any constitutional affection, such as gout, scurvy, syphilis or anæmia.

Local.—The local treatment aims at causing fresh exudation from the bones, and also at removing any local cause which may interfere with union. It is well to preface the operative measures by a course of massage so as to improve the circulation and the muscular tone of the limb; sometimes consolidation takes place during this treatment.

Various methods have been employed for producing fresh exudation at the seat of fracture, but the only plan that is in any degree an alternative to operation is the injection of irritating substances between the fractured ends. This is sometimes efficacious when there is only slight separation. A needle of suitable length is thrust through the skin and between the ends of the bones. Two or three minims of tincture of iodine are then injected at various points around the seat of fracture, and the limb is put up in a retentive apparatus. In some cases the irritation thus produced has been sufficient to secure consolidation of the fracture.

Operative Measures.—The plan adopted by practically all surgeons at the present day is to expose the seat of fracture, remove the material between the fractured ends along with a thin layer of bone, so as to obtain a fresh surface and bring the fragments into apposition and fix them securely. The operation must be done with the strictest aseptic precautions (see Vol. I. p. 99).

When there is only a single bone, e.g., *the femur or the humerus*, the chief steps in the procedure are as follows:—

The fracture is exposed by a free incision, so planned as to give the most direct and satisfactory access to the bone. Much help on this point may be gained by the aid of a radiogram. The incision should be in the long axis of the limb. The fracture is exposed without detaching the periosteum, and a thin layer of bone is chiselled off each fractured surface and removed along with the intervening fibrous tissue.

If the fractured ends overlap, extension must now be made, either by an assistant or by means of pulleys, and any tense bands should be carefully divided, provided they do not contain structures of importance. If necessary, muscles may be divided at their origin or attachment in order to allow the bone ends to come into apposition. In old cases with much shortening, it often happens that full reduction cannot be obtained even after free division of the soft parts; the bone surfaces must then be cut obliquely, and so arranged that they may be fastened together in the best position attainable.

The bone ends should be cut so that one fragment will not be rototed with regard to the other when the two freshened surfaces are applied to one another. In these cases, where there is only a single bone, one fragment is very apt to be rotated in a different direction to that in which the other is; and therefore, if the bone surfaces are cut so that the relative positions of the two fragments remain unaltered when they are applied together, the limb may be in a faulty position.

In dealing with limbs in which there is only a single bone, it is always well to use some mechanical means to retain the fragments in position. Ununited fractures unite slowly after operation, and, apart from the increased security from the mechanical fixation of the bony surfaces, the presence of these foreign bodies may assist union by giving rise to a certain amount of persistent irritation at the seat of fracture.

Fixation Methods.—Many methods have been devised for fixing the fragments together, but the choice generally lies between a wire, a screw, a peg, or a metal plate fastened with tacks or screws. The method employed will depend to some extent upon the individual preference of the operator, but there are certain general rules which should be borne in mind. It is not advisable to use plates and screws of two dissimilar metals, since these form a galvanic couple, the current produced by which causes disintegration of the surrounding tissues. The same objection applies to silver-plated screws, viz. steel screws which are first coated with copper and then silver-plated. Any breach in the plating exposes the underlying copper or steel, and in this way sets up an electrical current; if screws are used, they should be steel throughout.

Silver acts to a certain extent as an antiseptic, even in the metallic form; and hence, *cæteris paribus*, when there is any doubt as to the asepsis of the wound, as, for example, in compound fractures, a silver wire should be employed in preference to a steel plate. The condition of the fracture itself will also determine the method to be employed. When the

tendency to separation is in the long axis of the bone, as in the patella and olecranon, a wire is to be preferred ; but when the tendency is to lateral deviation or over-riding of the fragments, as in a transverse fracture of the shaft of the long bones, steel plates fastened with steel screws are the best appliances to use. When a fragment of bone has been detached, as, for example, in a fracture of the internal condyle of the humerus, screwing or pegging is the best method of fixation; but in young children the bones are sometimes so soft that a screw will not hold, and in these cases a wire can sometimes be employed with advantage. The great advantages possessed by screwing and pegging over wiring in the majority of fractures is that, besides the increased rigidity the screws or pegs ensure, the manipulations necessary for their application are

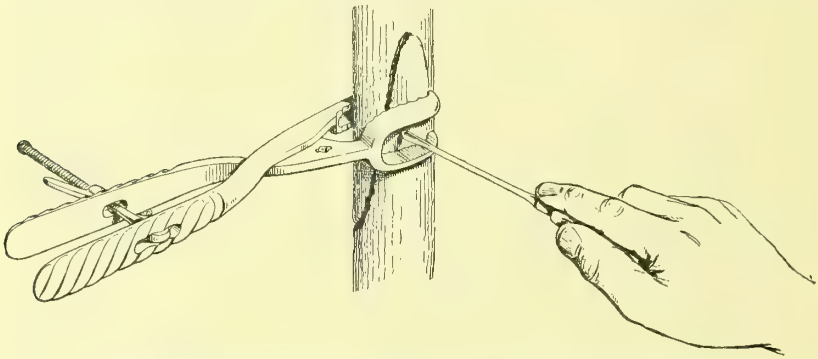


FIG. 130.—PETERS'S FORCEPS. As shown in the diagram, the fragments can be held firmly in apposition while the bone is being drilled. These forceps are provided with an extra blade which can be made to replace the one shown uppermost in the figure. The one here represented is the larger, and is employed when screws are to be used ; the smaller one is designed for use when wires are to be inserted.

much simpler than when a wire is inserted ; in the latter case the ends of the bone have to be freed much more widely from the soft parts. The details of the various operations for securing the fragments in the different fractures are given below.

Wires should be inserted as follows:

In the case of an oblique fracture, two holes are bored side by side through each fragment ; the corresponding holes in each fragment should come opposite each other, and are best made by one insertion of the drill through the entire bone, the fragments being held in exact apposition while they are drilled. A very useful pair of forceps for holding the fragments together during wiring or screwing is shown in Fig. 130. The end of a stout piece of wire is then passed through the corresponding holes in each fragment on one side, and then back through the corresponding holes on the other side (see Fig. 131). The loop of wire thus binds the fragments fairly firmly together. The ends are pulled tightly together, twisted, cut short, and hammered down so as to lie flat on the bone.

In cases of transverse fracture, however, wires are not satisfactory, but they are of some value if better means are not at hand, because, although they do not fix the bones firmly together, they tend to prevent the sliding of the fragments upon one another, and so obviate lateral displacement. Usually it is sufficient to pass a couple of single wires through opposite sides of the bone, bringing the ends out through the medulla above and *vice versa* below (see Fig. 132), the ends being twisted, cut short, and hammered down as before.

Ivory pegs are a good deal employed, but they possess the disadvantage that they tend to become loose and allow a certain amount of movement unless square pegs are used, which fit the drill hole tightly. These are

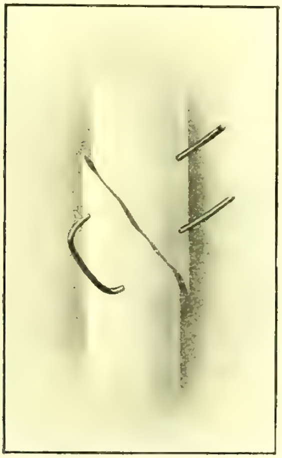


FIG. 131.—METHOD OF WIRING AN OBLIQUE FRACTURE. Here a single wire is used.

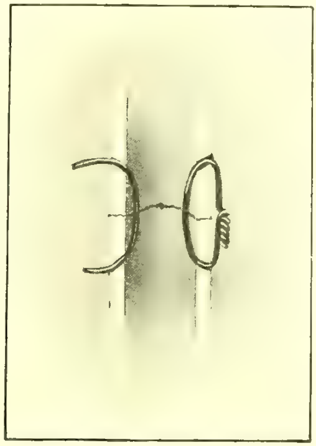


FIG. 132.—METHOD OF INTRODUCING THE WIRES IN A CASE OF TRANSVERSE FRACTURE. Here two separate wires are used.

more easily driven in than round ones, and get a firmer hold. The pegs are usually made 3 inches in length, but it is well to have them quite 6 inches long, as they are then driven in much more conveniently and with less danger of bruising the soft parts. When in position, the projecting end is cut off flush with the surface of the bone by cutting pliers. These pegs are now only used for securing fractures in the vicinity of joints where a plate applied to the surface might interfere with movements, *e.g.* fractures of the neck of the femur.

In the great majority of fractures, however, particularly those in which the displacement is lateral or over-riding, the best fixation can be obtained by applying *a metal plate*. For this purpose the steel plates devised by Mr. Arbuthnot Lane are now widely used. They consist of flat bars of steel of various shapes and sizes (see Fig. 133), provided with

countersunk holes for the insertion of screws. The screws[1] resemble the ordinary type used by carpenters, but the thread is cut right up to the head as shown in Fig. 135. They should exactly fit the plate with which they are to be used, so that their heads are flush with it; they should be long enough to go right through the compact shell of the bone.

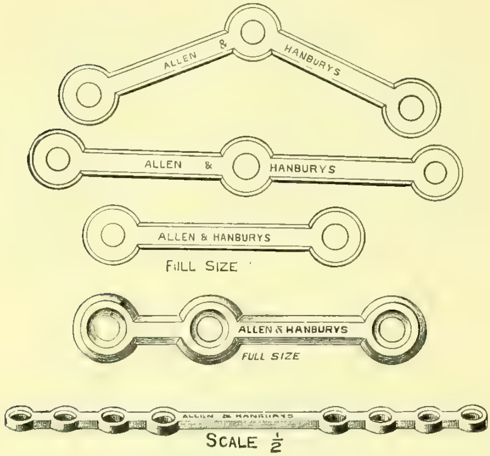


FIG. 133.—LANE'S BONE PLATES. The sketch shows a few of the various shapes and sizes of the plates; there are many others. the plates may be had either dead hard—in which case they are rigid,—or not so highly tempered—when they may be bent to any required shape. All the screwholes are countersunk.

As many of these plates have to be inserted at the bottom of a deep wound, *e.g.* in the thigh, the special forceps shown in Fig. 136 will be found a most useful aid while they are being put in. With them there is no fear of the screw slipping or being driven in obliquely, consequently its head will always be flush in the countersunk plate.

These steel plates have largely replaced the aluminium collars that we formerly employed. These consist of fairly stout sheet aluminium, in which holes are bored about half an inch apart (see Fig. 137). A piece

[1] The head of the screw may be with advantage slightly undercut as shown in Fig. 134, *B*. Such screws may be purchased, or the under-cutting (*c*) may readily be done with a fine hack saw or a thin file. These undercut screws are for use with a special screw-driver shown in Fig. 134, *A*. This bears four notches (*a*) just above its edge (*b*), so arranged that when the screw-driver is inserted into the slot in the head of the screw and slightly rotated, the notches engage beneath the undercut margins of the slot and prevent the screw-driver from slipping out. With this device it is possible to insert the screw without exercising any pressure and, therefore, without displacing the fragments. It requires a little practice to get out of the habit of forcing the screw-driver into the slot of the screw, but, when once the surgeon has accustomed himself to twisting the screw-driver without exerting any pressure, this form of screw-driver will be found a distinct improvement on the ordinary type.

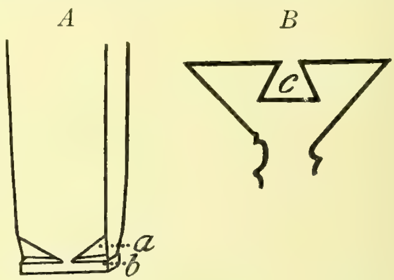


FIG. 134.—NON-SLIPPING SCREW-DRIVER AND SCREWS WITH UNDERCUT MARGINS IN THE SLOT. The description is given in the text.

is cut long enough to overlap the fracture about an inch and a half in each direction, and wide enough to embrace about three-fourths of the circumference of the bone. In the case of a triangular bone, two narrow slips may be cut, one for each side of the bone. These are fastened on with ordinary tin-tacks or small steel screws. This method is generally inferior to that just described, but it has the advantage that a plate of any size and shape can be fashioned in a few minutes with a stout pair of scissors.

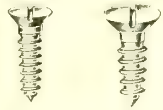


FIG. 135.—SCREWS FOR USE WITH LANE'S PLATES. There are different sizes of screws for the different plates: the drawing is full-size.

It is well not to detach the periosteum from the ends of the bone; no doubt there is less risk of bleeding if it be detached, but it is possible that the delay in union is to some extent increased by this detachment, and the plates can be fixed outside the periosteum quite firmly. The bone should always be bored for the reception of screws or pegs with a drill of suitable size; it is very important to have a series of drills corresponding to the various sizes of screws, and the one selected should be a trifle smaller than the screws that are to be used. If a fine drill be used for a stout screw, there will be great risk of splitting the bone.

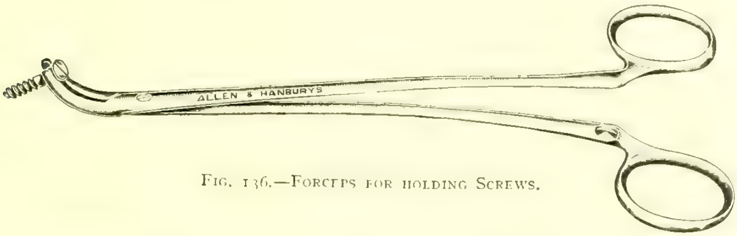


FIG. 136.—FORCEPS FOR HOLDING SCREWS.

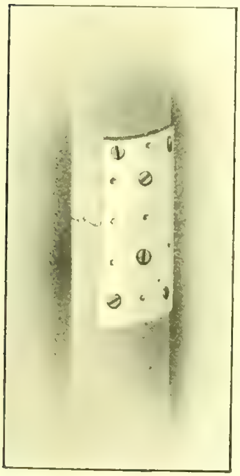


FIG. 137.—A FRACTURE SECURED BY MEANS OF A PLATE OF ALUMINIUM SCREWED ON TO THE BONE.

Bone-grafting.—When the ends of the bone are atrophied, or when there is a considerable interval between them, bone-grafts may be employed with advantage. These are best obtained from the ends of the bones themselves. Portions of the bone along with the periosteum are chipped off by a chisel and wedged in between the fragments; naturally, wiring or pegging the bones cannot be attempted here, but Lane's plates may be applied.

When the non-union affects a part, such as the leg or forearm, in which there are two parallel bones, care must be taken that the ends of both bones come into apposition. This is usually

easy if both bones be ununited, but, when the non-union affects one bone alone, the fractured ends, when refreshed, may not come into apposition on account of the rigidity of the other bone ; if the interval be large the best plan is to divide the sound bone, remove an amount of it corresponding to the interval between the fragments of the ununited one, and to fix the ends of both bones together by mechanical means so as to prevent lateral displacement. When, however, the interval is very small and only one bone is ununited, we would recommend the insertion of bone-grafts between the fragments, as preferable to the division of both bones, because the sound bone acts as an efficient splint.

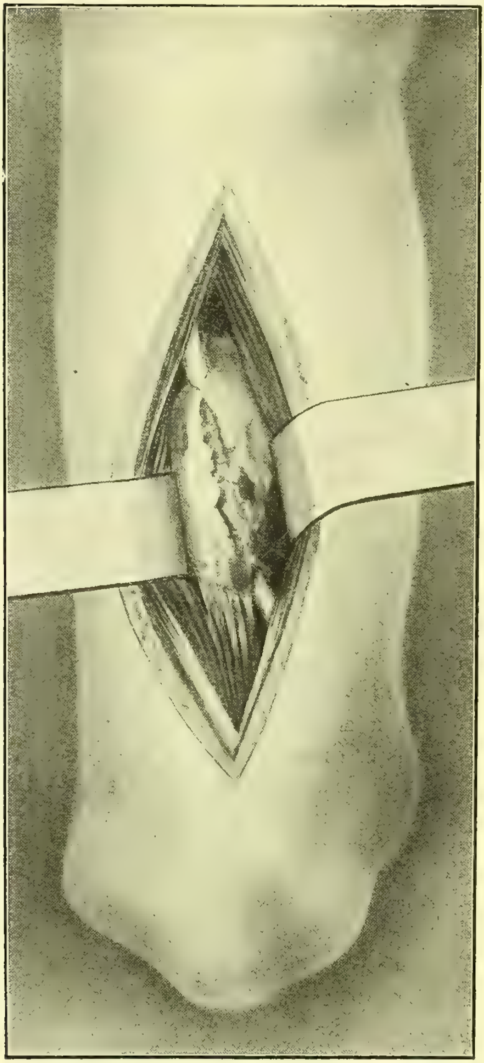


Fig. 138.—Inclusion of the Musculo-Spinal Nerve in Callus in a Fracture of the Lower Third of Humerus.

After-treatment.—The wound is closed without a drainage tube and the limb immobilised. The best plan is to incorporate in the dressing splints of sterilised block tin or wire-netting moulded round the limb, in the manner already described for compound fracture, so as to fix the neighbouring joints. Further fixation apparatus, for example a Gooch's splint, may be applied outside these if necessary. The dressing need not be changed until it is desired to remove the sutures, unless it be much saturated with blood. If it be necessary to change it soon after the operation, it is well to give an anæsthetic and to re-apply the splints before the patient comes round from the

anæsthetic. It may be necessary to immobilise the limb for more than three months, and if union is delayed massage and Bier's bandage may be of value.

Inclusion of Nerves in the Callus.—The large nerves which run in grooves along or in close proximity to the bone may be surrounded by callus which exerts pressure upon them as ossification goes on, and gives rise to pain and loss of function.

The *treatment* has already been referred to (see p. 112).

Adhesion of Muscles and Tendons to the Fractured Ends.—There may be extensive adhesions of the muscles to the bones, and it is important to remedy the resulting disability of the limb when this has occurred.

The *treatment* has been dealt with fully in connection with the question of massage in fractures (see p. 280).

Swelling of the Limb on using it.—This is a fairly frequent, though transitory, complication of fractures in the lower extremity. Unless some of the principal veins are blocked, it disappears spontaneously in a short time. The complication can be reduced to a minimum and its disappearance greatly hastened by the early use of massage (see p. 280).

CHAPTER XV.

FRACTURES OF THE CLAVICLE AND SCAPULA.

FRACTURES OF THE CLAVICLE.

THE clavicle is more often fractured than any other bone. This is due to the fact that the whole weight of the body is transmitted to it in falls upon the hand or elbow; it would probably be much more frequently fractured than it is but for its peculiar shape and its comparatively free mobility. Fracture is most common in infancy and childhood and in the male sex, but it is frequent at any age, and in both sexes. The fracture may occur at almost any point in the bone, but its usual situation is at the junction of the two curves near the centre of the bone, and, far less frequently, at the acromial or the sternal extremity. All these fractures may be due either to direct or indirect violence; they may be simple, compound, greenstick, or comminuted.

DISPLACEMENT.—*In the Ordinary Form.*—In the common fracture at the junction of the two curves—which is generally due to indirect violence—there is a characteristic displacement of the fragments. The shoulder, and with it the outer fragment, is depressed, rotated forwards and drawn inwards towards the middle line. The inner fragment retains its normal position, as it is held in place by the unbroken rhomboid ligament. In some cases it is said to be drawn upwards by the sterno-mastoid; this, however, is doubtful.

In Fracture of the Acromial End.—In fractures between the conoid and trapezoid ligaments, the displacement downwards and inwards characteristic of the ordinary fracture is absent; the only one that occurs is rotation forwards of the shoulder, which may be some days before it becomes marked. This point is important to remember, because the accident may at first be overlooked, owing to the absence of displacement, and the diagnosis may not be made until deformity becomes evident.

In Fracture of the Sternal End.—When the fracture is internal to the rhomboid ligament there is only slight projection forward of the inner

fragment which practically consists of the articular portion of the sternal end of the clavicle.

COMPLICATIONS.—Complications are rare and usually only occur in fractures from very severe violence. The most frequent is injury to, or *pressure upon the brachial plexus*, leading to severe neuralgia of the upper extremity and, in bad cases, to paralysis. Paralysis due to this cause is present before the fracture is reduced; when it occurs after reduction, it is generally due to a pad in the axilla exerting undue pressure upon the nerves there. When the fractured ends are much comminuted from severe direct violence, there may be a *wound of the subclavian artery*, which may lead to immediate death from hæmorrhage, to the occurrence of a large hæmatoma, or to the formation of a false aneurysm. True aneurysm has also followed a fracture of the clavicle as a result of bruising of the coats of the artery. *Wounds of the pleura and* even of *the lung* have also been described in connection with these fractures, but they are rare and are generally accompanied by fracture of the first rib.

FIG. 139.—THE HANDKERCHIEF METHOD FOR TREATING FRACTURED CLAVICLE. The shoulders are well pulled back by the handkerchiefs looped around them, and the arm is supported by a large elbow sling tied over the sound shoulder. The apparatus is completed by the handkerchief encircling the thorax and binding the arm to the side.

TREATMENT. — **Of the Ordinary Form.**—The treatment must be directed towards correcting the threefold deformity, that is to say, the outer fragment must be carried outwards, upwards, and backwards. The results of treatment are rarely perfect as regards appearance, but the fracture unites readily and the functional result is almost invariably good.

Recumbency.—Should the patient be a lady, it will be very desirable to avoid leaving any deformity that would be noticeable when evening dress is worn, and the only method of ensuring this is to place the patient in bed on a hard, flat mattress with a small, narrow, hard pillow or pad between the shoulder blades and another supporting the nead only. The pillow beneath the spine must be very narrow, so that the edges of the

scapulæ do not rest upon it ; the weight of the shoulder thus carries the outer fragment backwards more completely than could be done in any other way. The elbow is raised and fastened to the side. This position must be maintained for a fortnight ; it is irksome, and few patients will submit to it. It is imperative, however, when both clavicles are fractured, and where, therefore, there is no sound shoulder from which to support the elbow.

The Handkerchief Method.—An excellent method is the old plan of pulling back the shoulders by means of two triangular handkerchiefs. Each handkerchief is folded to its centre over a roll of cotton wool a foot long, which is placed in the middle of the handkerchief ; in fact, the handkerchiefs are prepared much in the same way as is a perineal band and are fastened loosely around each shoulder, passing beneath the axilla and over the point of the shoulder without encroaching upon the seat of fracture. The ends of the handkerchiefs are tied together behind the back between the scapulæ ; in this way the shoulders can be pulled back to any degree required. The axilla should be shaved and powdered over with boric acid, and the arm supported by a large handkerchief sling, which raises and pushes forward the elbow and is fastened round the neck over the sound shoulder. A third handkerchief binds the arm to the side passing around the trunk just above the level of the elbow (see Fig. 139). The pressure of the knot in the middle of the back, which is very irksome, may be avoided by sewing the ends of the handkerchiefs together instead of knotting them, or by adopting the method illustrated in Fig. 140 where the shoulder loops are buckled together, and the tension can be varied at will. For adults we prefer this method to all others, at any rate during the early stages, as it relieves the pressure upon the nerves more completely than any other.

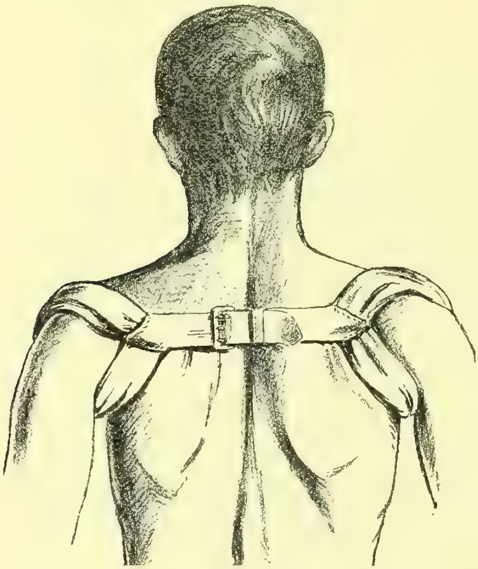


FIG. 140.—APPARATUS FOR PULLING BACK THE SHOULDERS IN FRACTURED CLAVICLE. The loops are made by encasing wool in several folds of muslin, and the requisite amount of retraction of the shoulders is easily regulated by the strap and buckle connecting them.

After-treatment.—Gentle massage to the area of the fracture should be practised from the first. The apparatus may need tightening from time

to time and will probably require renewal in about a week, when passive movements of the shoulder should be carried out. The shoulder loops may be left off in a fortnight and the sling in about three weeks. The massage should be continued throughout.

Sayre's Method.—The method most commonly employed in fracture of the clavicle is that known as Sayre's, or some modification of it. The arm and chest should be shaved, and the hair in the axilla cut short and powdered with boric acid. A strip of adhesive plaster, three inches broad for an adult, and two inches for children, is looped around the centre of the arm, with the non-adhesive side next the skin, and the ends of the loop pinned to prevent them slipping. If the strapping be merely wound round the arm, contriction of the limb will occur when it is pulled on ; the loop must be wide enough to allow three fingers to be inserted between the strapping and the skin. The arm is pulled back as far as possible by traction on the strip of plaster (see Fig. 141), which is then carried horizontally across the back, round beneath the opposite axilla and across the front of the chest, so as to encircle the thorax. It is finally pinned to itself just beyond the loop around the arm. The strapping thus applied acts as a fulcrum which enables the shoulder and the outer fragment of the clavicle to be carried backwards when the elbow is pushed forwards.

Fig. 141.—Sayre's Apparatus for Fractured Clavicle. *Applying the arm loop.* The arm is pulled forcibly backwards by traction upon the strapping, which is afterwards fastened as shown in the following figure.

An assistant then flexes the elbow, carrying it forwards and upwards until the fingers touch the opposite shoulder and the forearm lies across the front of the chest (see Fig. 142). A second strip of strapping is now carried over the sound shoulder obliquely downwards across the back to the point of the elbow, where an oblong slit is made in it for

the reception of the olecranon ; thence it is carried up to its starting-point over the sound shoulder, and the two ends are pinned or sewn together (see Fig. 143). This completes the apparatus, but it is advisable to apply a bandage over all in addition, and it is well to sew the adjacent edges of the bandage together or to rub starch solution into it.

Fig. 142.—Sayre's Apparatus for Fractured Clavicle. *Pushing forward the elbow and pulling back the shoulder.* The arm loop acts as a fulcrum. The arrows show the direction in which the hands exert pressure.

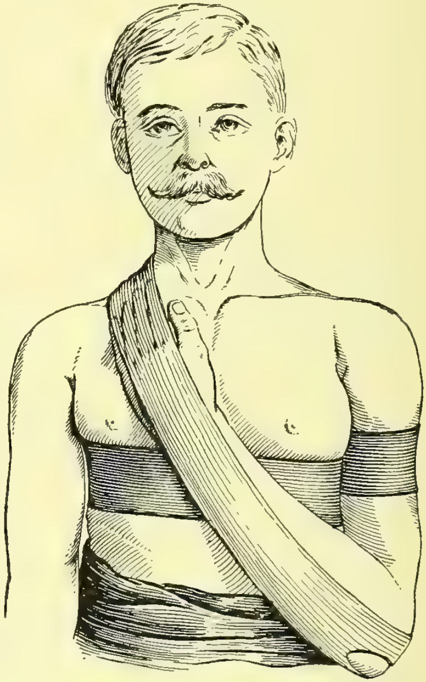


Fig. 143.—Sayre's Apparatus for Fractured Clavicle. *Supporting the elbow.* The apparatus is now complete except for a bandage over all. The hand need not necessarily be included as shown in the figure.

This apparatus should be kept on for nearly three weeks, after which the arm is carried in a large elbow-sling for a week. Should it become loose in the interval it must, of course, be renewed. Union takes place very rapidly, and an ununited fracture of the clavicle is rare. Movements at the elbow and shoulder should be performed daily after the first week.

Of Fracture of the Acromial End.—When the fracture is in the neighbourhood of the conoid and trapezoid ligaments, either the handkerchief arrangement or Sayre's apparatus should be applied, even though

no deformity exists when the patient is first seen ; this is necessary to prevent the tip of the shoulder rotating forwards at a later period.

Of Fracture at the Sternal End.—When the fracture is at the sternal end, the treatment depends upon whether there is any deformity and whether there is any other fracture present. Usually there are other injuries, so that the patient is confined to bed ; it then suffices to keep him lying on his back with a pad between the scapulæ. When there are no other injuries, Sayre's method is the most suitable.

Of Greenstick Fracture.—Greenstick fractures should be treated in the same manner as the complete varieties ; care must be taken to reduce the deformity when the case is first seen by carrying back the shoulder with one hand and pressing on the projection with the other until the deformity has disappeared.

Of Compound Fracture.—If the fracture of the clavicle be compound, the case must be treated by the methods ordinarily employed for compound fracture (see p. 283). The wound and, if necessary, the ends of the bone are purified, and the fractured ends are fastened together by silver wire or a plate ; a drainage tube should be used, in case complete asepsis has not been secured. The patient should lie upon his back with a narrow pillow along the spine, and the bandages should be so arranged as to pull the shoulders well back and to support the elbow ; good union usually takes place. Since union in compound fractures is not so rapid as in simple ones, the apparatus may have to be kept on for at least six weeks.

FRACTURES OF THE SCAPULA.

VARIETIES.—Fracture of the scapula may occur in the body, the neck, the acromion, or the coracoid process.

Fracture of the Body.—The body of the scapula is rarely fractured, owing to its extreme mobility and to the protection afforded by the muscles over it. It is generally caused by severe direct violence, such as a blow upon the back in buffer accidents and the like. It is often complicated by other fractures in the vicinity, such as fracture of the ribs beneath and is not uncommonly comminuted ; it occurs more frequently in the infra-spinous than in the supra-spinous fossa.

Fracture of the Surgical Neck.—This form of fracture is generally produced by a fall upon the out-stretched hand, but is sometimes due to a fall directly upon the point of the shoulder.

Fracture of the Acromion.—Here the cause is generally direct violence, such as a fall or a downward blow upon the point of the shoulder.

Fracture of the Coracoid Process.—As the coracoid process is deeply seated and well protected, fracture of it is usually accompanied by other injuries, such as fracture of the clavicle or the upper ribs, or dislocation of the humerus, and is due to direct injury.

SYMPTOMS.—*Fracture of the body of the scapula* is characterised by extreme pain, and inability to move the shoulder. There is also generally considerable swelling from extravasation of blood, and crepitus is sometimes felt when the hand is placed over the scapula and the arm moved, or when the fragments are grasped and rubbed one on the other. *In fracture of the acromion process* there is inability to raise the arm from the side, and the shoulder presents a slightly flattened appearance. The fractured portion is pulled downwards, chiefly by the deltoid. *In fracture of the coracoid process* the detached fragment is often drawn downwards and inwards by the three muscles attached to it ; but when the ligaments between the coracoid process and the clavicle are intact, little or no deformity is present. *Fracture of the neck of the scapula* is one of the injuries which has to be distinguished from dislocation of the shoulder. It is generally accompanied by some flattening of the shoulder, but the arm is lengthened instead of being shortened. The contour of the shoulder can be restored by pushing up the elbow, and crepitus generally occurs at the same time. As soon as the elbow is allowed to hang again, the deformity is reproduced. When the fracture runs through the neck, the coracoid process also descends with the arm. In extremely rare cases, fracture of the glenoid cavity occurs, and the coracoid process remains connected with the rest of the bone. In all cases the X-rays are required to localise the fracture exactly.

TREATMENT.—**In fractures of the body of the scapula** the important point is to keep the bone at rest until union has taken place. With this object the elbow, supported by an assistant, is held slightly away from the side, and a thick layer of cotton wool is applied over the back of the scapula and secured firmly in position by a broad bandage or by strips of strapping applied around the side of the thorax, so as to press the bone against the chest. After shaving the axilla and powdering it with boric acid, the forearm is put in a sling which supports the elbow, the arm is brought to the side, a ring-pad is inserted between the internal condyle of the humerus and the ribs, and the arm is bandaged firmly to the chest. Some starch solution is then rubbed into the bandages to prevent them from slipping, and the apparatus is kept on until the end of the second week, when it is removed and the patient is encouraged to move the arm, and massage is begun.

Fracture of the acromion process is more difficult to treat. The ideal treatment is to place the patient in bed in the horizontal position, with the arm stretched out at right angles to the side of the chest, so as to relax the deltoid, and prevent it from pulling the fragment downwards. This position, however, is most irksome, and will hardly ever be tolerated. The best alternative is to push up the head of the humerus against the under surface of the acromion, and to fix it there, with the object of keeping the fragment as nearly as possible in its normal position. No pad should be inserted in the axilla, as otherwise the head of the humerus

will not act properly on the acromion; a small pad should be placed betweeh the internal condyle and the ribs, and the forearm should be flexed across the chest. Then the arm and the forearm are bound firmly to the side by a bandage or strapping. It is well to keep the arm in this position for a month at least, but in many cases a certain amount of deformity persists, the point of the acromion being tilted somewhat downwards. This does not necessarily give rise to any disability, but there may be weakness of the arm, and, therefore, if the acromion is much drawn down when the case is first seen, it is well to operate and fix the two fragments together by one or more plates (see p. 305).

Fracture of the neck of the scapula can be readily reduced by pushing up the elbow, which should be kept in that position until union occurs. The axilla should be shaved and powdered and a pad placed in it; the arm is then supported by a large elbow-sling and is bound to the side by a handkerchief or bandages. If bandages be employed, they should not only encircle the chest and arm, but should also pass diagonally below the elbow on the affected side and over the opposite shoulder, so as to give additional support to the arm. This apparatus must be kept on for four or five weeks; if it be removed earlier, the deformity is almost certain to recur. As, however, stiffness of the shoulder joint is very liable to result from the presence of adhesions within the capsule, it will be necessary to commence passive motion after the lapse of about a week.

Two persons are required to carry out this passive movement in order to avoid displacing the fragments. The surgeon fixes the scapula as well as he is able from the axilla—a matter of great difficulty in fat patients—while the assistant, keeping the arm well pushed up, moves it cautiously in all directions. This passive movement should be very gentle at first and moderate in range, and should be repeated daily for the first week, after which time it may be employed more frequently and more freely. In the intervals the arm should be kept in the sling or apparatus above described, which should not be wholly discarded for about five weeks.

Fracture of the coracoid process, if accompanied by comparatively slight displacement, is best treated by carrying the elbow as far forwards and upwards as possible, so as to relax the pull of the muscles upon it. The position of the arm is practically that employed in cases of fracture of the clavicle. The arm should be firmly bound to the side and the elbow supported. If, however, there be considerable displacement, and no contra-indication to operation exists, the best plan will be to cut down over the anterior edge of the deltoid, expose the coracoid process and fasten it to the scapula. This fracture, however, is extremely rare, and is often complicated with other severe injuries, so that this operation will seldom be called for.

CHAPTER XVI.

FRACTURES OF THE HUMERUS.

Fractures of the humerus are usually divided into those affecting the upper end, the shaft, and the lower extremity.

FRACTURES OF THE UPPER END OF THE HUMERUS.

These comprise fracture of the surgical neck, fracture of the anatomical neck, separation of the upper epiphysis, and separation of the great tuberosity. Fractures of the upper end of the humerus may result from direct or indirect violence ; the fractures of the surgical neck are generally produced by indirect violence, such as falls upon the hand or elbow, while the other fractures usually result from direct violence.

FRACTURE OF THE SURGICAL NECK OF THE HUMERUS.

This is the most important and most frequent of the fractures of the humerus. It may result from either direct or indirect violence, in the former case from a fall upon the shoulder, in the latter from a fall upon the outstretched hand or elbow. The line of fracture is usually transverse, and the fractured ends are not always separated from one another ; in some cases impaction of the lower fragment into the upper takes place. The displacement that occurs depends largely upon whether or not tne fragments are entirely disentangled. When separation of the fragments is complete, the following are the chief displacements. Opinions differ considerably as to the displacement of the upper fragment, some holding that it is but slightly altered in position, whilst others assert that it is abducted and rotated outwards by the muscles inserted into the great tuberosity. The tendency to rotation outwards is, however, counterbalanced to a considerable extent by the pull of the subscapularis, and the probability is that, unless the bone be displaced by the violence producing the fracture, it remains much in its normal position. The lower fragment is drawn upwards either in front of or behind the upper

fragment. It usually passes up in front, and is felt below the coracoid process, forming a projection beneath the anterior fold of the axilla. Below the projection formed by the lower end of the upper fragment there is a depression opposite the insertion of the deltoid, and the elbow is directed somewhat away from the side. This accident may be complicated by dislocation of the head of the bone ; probably the dislocation occurs first and the fracture takes place subsequently.

TREATMENT.—The treatment employed for fracture of the surgical neck of the humerus is, in the main, the one most suitable for the other fractures about the upper end of the bone.

Fig. 144.—Method of securing a Pad in the Axilla. A piece of bandage is fastened to each end of the axillary pad and these are made to form a figure-of-eight as shown above.

Reduction.—In order to reduce the fracture satisfactorily, the patient should be put under an anæsthetic. The scapula and shoulder are fixed by an assistant whilst the surgeon reduces the fracture by making e x t e n s i o n downwards and outwards, so as to bring the lower fragment down to its proper level as a preliminary to manipulating it outwards and backwards with the left hand in the axilla, until the fractured surfaces have been brought into accurate apposition. When the line of fracture is transverse, there is little risk of recurrence of the displacement after reduction has been properly effected ; when, however, the fracture is oblique, displacement is likely to recur, and the limb requires very careful immobilisation.

Retentive Apparatus.—If the fracture be transverse, a simple arrangement will suffice to retain the fragments in position after the fracture has been reduced. The axilla is dusted with boric acid, and a pad (see Fig. 144) is placed in it to prevent displacement inwards of the lower fragment. The elbow is flexed, and the arm brought vertically down to the side. The base of a large triangular bandage is fastened horizontally around the arm and trunk just above the elbow. The apex of the bandage hangs downwards, and is turned up around the forearm and the point of the elbow, between the limb and the chest, over the base of the handkerchief, to which it is finally pinned (see Fig. 145). The wrist is supported by a narrow sling.

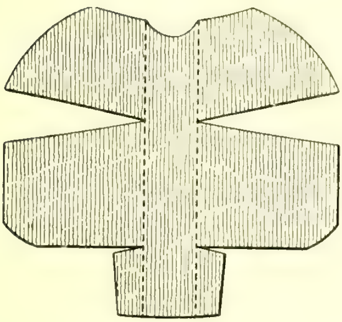
In this form of fracture there is no need for any special extension apparatus. It is, however, often the practice to put on a shoulder-cap for greater safety. In order to fashion a shoulder-cap, a sheet of brown paper is applied to the sound shoulder, and from it is cut a pattern for the shoulder-cap (see Fig. 146, *A*), which should extend from the root of the neck above nearly down to the elbow-joint below, and well over the

FIG. 145.—BANDAGES APPLIED IN TRANSVERSE FRACTURE OF THE UPPER END OF THE HUMERUS. The left-hand figure shows how the triangular bandage is applied horizontally around the thorax after the fracture has been reduced and a pad placed in the axilla. The other figure shows the apparatus completed. The point of the triangular bandage is turned up around the forearm, between it and the chest, and turned over and pinned, as shown above. A narrow wrist-sling is then put on, with a shoulder-cap over all.

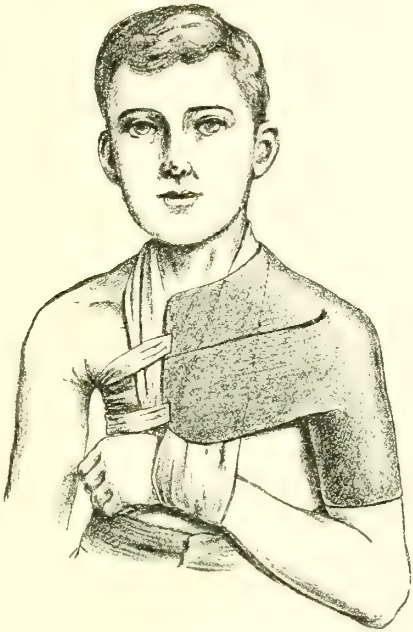
pectoral and scapular regions. Lower down it should encircle two-thirds of the circumference of the arm (see Fig. 146, *B*). The pattern, when cut, is laid upon a sheet of gutta-percha, poroplastic, or leather, which is then cut to this shape; poroplastic is, perhaps, the most manageable and comfortable material. The splint is then softened. If it be of gutta-percha, it is immersed in hot water; if of poroplastic, it is warmed before a hot fire or steamed in a steriliser; if of leather, it is immersed in vinegar. The splint is applied to the injured side and rapidly fitted, moulded and bandaged in position, while it is still soft. If gutta-percha or poroplastic

be used, the limb should be wrapped in a layer of wool or a folded towel before the splint is applied, as otherwise the skin may be burned.

Leather or gutta-percha splints should be removed from the limb, and a number of holes punched in them before they become quite hard, to allow of the escape of perspiration. These holes should be punched from the inner surface, as if done in the reverse direction the points of the punctures will irritate the skin. After the splint has got quite hard, it is removed, padded, and finally reapplied by means of tapes attached to the



A



B

FIG. 140.—SHOULDER-CAP FOR USE IN FRACTURES OF THE HUMERUS. *A* shows a pattern suitable for a shoulder-cap which is shown applied in *B*. The wrist-sling is placed beneath the shoulder-cap in order to obtain better fixation of the wrist. The splint is secured around the arm by a strap or bandage not shown in the figure.

upper part and passed under the opposite axilla ; it is fastened around the arm by straps and buckles.

A stereoscopic radiogram should be taken as soon as possible, in order to ascertain whether reduction has been satisfactorily accomplished.

After-treatment.—The apparatus should be left undisturbed for at least a week, unless it causes pain from pressure, or shifts its position. When it is removed, the axilla and arm are washed, and movements of the joint are gently carried out in all directions. While this is being done an assistant steadies the scapula, and the surgeon grasps the region of the fracture with one hand and moves the arm with the other. The fracture is then put up again, and the apparatus ought not to be

discontinued until about four weeks have elapsed. During the progress of the case the splint should be taken off daily after the end of the first week or ten days for massage and passive movement.

When the fracture does not keep in place satisfactorily after reduction, as may be the case when there is considerable obliquity or much comminution of the fragments, it will be advisable to expose the fracture and adopt some means of mechanical fixation (see p. 305), if a good result is to

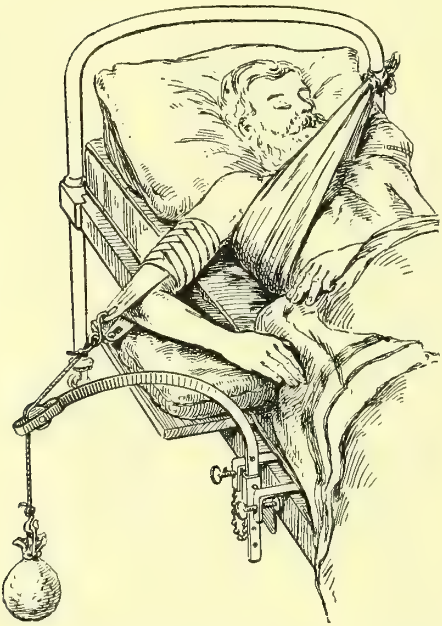


FIG. 147.—WEIGHT EXTENSION IN FRACTURE OF THE UPPER END OF THE HUMERUS. *Extension applied while the patient is in bed.* The pulley-arm is attached to the side of the bed and extension is made with the arm somewhat abducted. The counter-extension is made from the end of the bed in a line parallel with that of the extension; a large sling or a jack-towel is used for this purpose, and fixes the scapula and thorax.

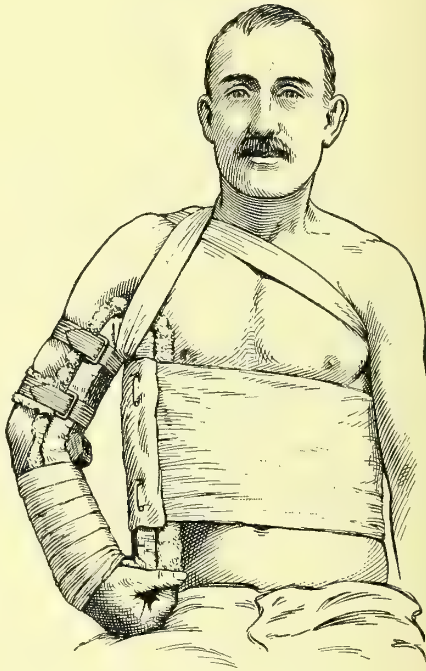


FIG. 148.—MIDDELDORPF'S SPLINT FOR FRACTURE OF THE SHAFT OF THE HUMERUS.

be obtained. It will only be in cases in which operation is distinctly contra-indicated by age or constitutional disease that any further trial of non-operative measures should be made. In default of operation, continuous extension should be employed.

Extension Apparatus.—Extension is often applied by inserting a pad in the axilla, fixing on a shoulder-cap (see p. 322), and supporting the wrist by a narrow wrist-sling. The elbow is left free, in order that the weight of the limb may act as an extending force. This method is not, however, entirely satisfactory, and if there be over-riding of the frag-

ments, some more efficient method must be employed because of the disability which follows these fractures if they are not kept in good position. The patient, therefore, should be kept in bed and a pulley extension apparatus applied to the upper arm, taking purchase just above the elbow. The arm should be away from the side, and the cord, with a weight of three or four pounds attached, should pass over a pulley at the side of the bed. There must be no rotation of one fragment upon the other. Counter-extension is made by a well-padded sling around the axilla, fastened to the head of the bed (see Fig. 147).

At the end of ten days the patient may be allowed to get up, wearing a shoulder-cap or a Middeldorpf's splint (see Fig. 148). Extension can also be made from the elbow, when the patient is up and wearing a shoulder-cap, by means of a weight of about three pounds, the hand being kept in a sling in such a position that one fragment is not rotated upon the other (see Fig. 149). At the end of the third week extension may be left off, but the shoulder-cap should be kept on for another week.

FIG. 149.—WEIGHT EXTENSION IN FRACTURE OF THE UPPER END OF THE HUMERUS. *Extension applied while the patient is up.* The weight is attached to the stirrup and a shoulder-cap and wrist-sling are put on. At night the two latter can be taken off and the extension applied as in the preceding figure.

Mechanical Fixation of Fragments.—In any case in which the fragments cannot be got into position, or in which the displacement recurs after reduction, there should be no hesitation in cutting down upon and fixing the fragments in position, provided that the patient be a fit subject for operation. This will be especially called for in those cases in which the fracture runs obliquely upwards through the tuberosities. A stereoscopic radiogram will show the exact displacement and will be of much help to the surgeon in planning his incision, so as to approach the fracture by the shortest route. The incision will vary with the fracture. Generally the choice is between one running almost vertically down from the tip of the acromion between the fibres of the deltoid, or one running down along the anterior border of that muscle, curving outwards and backwards below; its insertion may be partially detached, if necessary, to allow of proper access to the fracture. The fractured ends are got into position by means of manipulations aided by powerful extension exerted by an assistant. When the fractured surfaces are accurately applied to one another they are fastened together by means of Lane's plates (see p. 308). All bleeding is arrested and the wound closed, a few catgut sutures uniting

the muscle fibres. No drainage tube need be used. A shoulder-cap is applied outside the dressing, and the arm is bound to the side for the first fortnight. After that, the treatment is similar to that of a simple fracture.

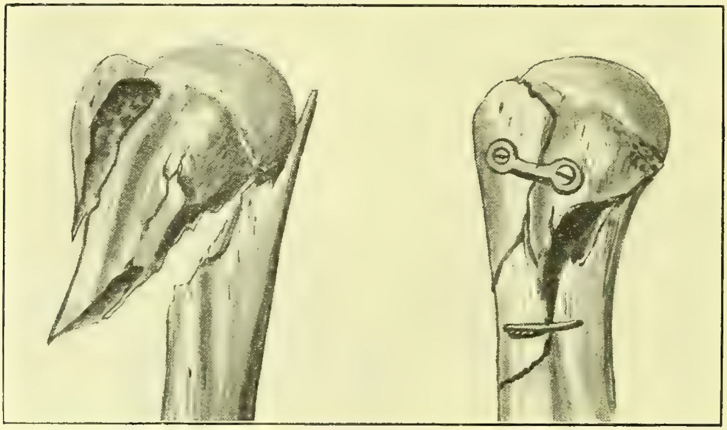


Fig. 150.—Repair of a Comminuted Fracture of the Upper End of the Humerus by means of a Silver Wire and a Plate.

FRACTURE OF THE ANATOMICAL NECK.

This is an injury of some rarity; it is more frequently met with in old people and corresponds in them to fracture of the neck of the femur. The line of fracture follows more or less completely that of the anatomical neck of the humerus and is, therefore, wholly or mainly within the capsule. The injury usually results from severe direct violence, such as falls or blows upon the point of the shoulder, and the resulting deformity is comparatively slight. The head of the bone may remain connected with the tuberosity by bands of untorn periosteum, but it may be completely separated and even rotated so that its cartilaginous surface is in contact with the fractured end of the lower fragment; in these cases, of course, there is no prospect of union. The shoulder is slightly flattened. The lower fragment is drawn somewhat upwards under the acromion, and the head of the bone may be driven into the tuberosity.

TREATMENT.—The chances of bony union are not good enough to encourage the surgeon to run the risk of getting a stiff joint. Therefore, the chief attention should be given to massage from the first and passive movements after the first fortnight. An axillary pad is unnecessary unless there be much tendency to displacement inwards. The elbow should not be supported, only a narrow wrist-sling being employed. The shoulder-cap need not be used, and the arm should not be fastened to the side. When the head of the bone is loose in the glenoid cavity—a

condition that a radiogram will make evident—and when, therefore, it is certain that no union will take place, it is best to cut down and remove the detached head. A freely movable joint may be obtained if passive movement be resorted to soon after operation.

FRACTURE OF THE GREAT TUBEROSITY.

The great tuberosity may be detached without any loss of continuity in the shaft of the bone. This accident gives rise to considerable broadening of the shoulder, the fragment being drawn upwards and backwards by the muscles attached to it.

TREATMENT.—In this fracture the continuity of the head of the bone with the shaft is unimpaired. The fragment may not be completely detached, and may be held fairly well in position by untorn bands of periosteum. The position most favourable for good union is to carry the arm out from the side nearly to a right angle, and to rotate it well outwards ; and this position is frequently recommended. A wedge-shaped pad, the upper angle of which is a right angle, or a well-padded splint of a similar shape, is placed in the axilla with its apex upwards in order to keep the arm in this position ; a thick flat pad is placed over the great tuberosity, and the whole is fixed in position by a bandage. This position is most irksome, and as there may be much difficulty in getting the fragment into position, the only really satisfactory method of treatment is to make a vertical incision, split the fibres of the deltoid, and fix the detached tuberosity in place mechanically. Special care must be taken not to injure the circumflex nerve, otherwise paralysis of the deltoid will result. This injury is rare, and the force which produces the fracture is generally so severe that there are likely to be other injuries in the vicinity which may modify the treatment.

SEPARATION OF THE UPPER EPIPHYSIS.

This occurs in subjects under the age of 20, and corresponds closely in its characters to fracture of the surgical neck.

TREATMENT.—The injury resembles fracture of the surgical neck so closely both in appearance and treatment that what has already been said with regard to the one may be taken as applying to the other. This particular injury possesses the added gravity that there may be arrest of development in the humerus following the damage to the epiphyseal line and, as a considerable proportion of the growth in the bone takes place at the upper epiphysis, this may lead to marked shortening. Hence an operation for fixation of the fragments should be performed at once unless the position after reduction is quite satisfactory.

COMBINED FRACTURE AND DISLOCATION.

Dislocation of the shoulder is not infrequently combined with fracture of the surgical neck of the humerus.

TREATMENT.—The general rule of treatment up to the present time has been that if the head of the bone cannot be got into position by manipulation under an anæsthetic, the fracture should be put up with the lower fragment in a line with the displaced head and upper fragment, and that when consolidation has occurred, a second attempt should be made to reduce the dislocation. But it is not only difficult, but dangerous to attempt to reduce a dislocation of the shoulder that has remained unreduced for even a few weeks. It is certain that by the time the fracture has united firmly enough to permit sufficient force to be applied to reduce the dislocation, reduction would be impossible, on account of the changes in the capsule and adhesions between the head of the bone and the surrounding structures. Hence it is far better practice to cut down, replace the head of the bone at once and suture the rent in the capsule, and then fasten the fractured ends together. The steps of the operation for reduction of the dislocation are described in connection with dislocations (see Vol. III.). The most efficacious method in this particular condition seems to be to make traction upon the limb vertically upwards, while the surgeon manipulates the head of the bone through the axilla.

FRACTURES OF THE SHAFT OF THE HUMERUS.

CAUSES.—The shaft of the humerus is most frequently broken just below the insertion of the deltoid, but fracture by direct or indirect violence may occur at any part. The most common cause is a direct blow upon the arm, but the fracture may also result from falls on the hand or elbow.

DISPLACEMENT.—The displacement varies according to the obliquity and situation of the fracture and the nature of the force producing it. If the bone be broken just above the insertion of the deltoid, the upper fragment is usually drawn inwards and forwards by the pectoral and other muscles, whilst the lower is pulled upwards and outwards, and the elbow is directed away from the side, so that there is a marked depression just above the insertion of the deltoid. When the fracture takes place below the insertion of the deltoid, the upper fragment is usually abducted and somewhat rotated outwards, whilst the lower fragment is drawn upwards to the inner side of the ppuer one.

COMPLICATIONS.—These fractures are usually unaccompanied by complications, but sometimes the musculo-spiral nerve may be injured at the time of the fracture, or it may become involved subsequently in the callus ; the result is paralysis of the extensors of the hand.

TREATMENT.—Fractures of the shaft of the humerus not infrequently fail to unite, and their treatment, therefore, demands special care. Probably the chief cause of non-union is neglect to fix the elbow-joint. In reducing the fracture it is well to employ an anæsthetic, as otherwise the muscular contraction may be very difficult to overcome and displacement may recur before the splints can be applied. Four splints are applied to the arm, viz., an internal straight one reaching from the axilla to just above the internal condyle; an anterior straight splint reaching from the level of the coracoid process to just above the antecubital fossa; a posterior splint, also straight, reaching from the level of the neck of the humerus to the tip of the olecranon; and a shoulder-cap which is prolonged below into an external angular splint reaching as far down as the lower third of the forearm. The short splints, which may be conveniently made of Gooch's splinting, should together be about two-thirds of the diameter of the limb in width, should be well padded, and fixed around the arm with straps and buckles. The elbow is flexed to right angle, and the forearm is put up in a position midway between pronation and supination. The wrist should be supported in a sling, and the arm fastened to the side (see Fig. 152). When the fracture is below the insertion of the deltoid, the arm should hang vertically at the side with the long axis of the forearm parallel to the antero-posterior plane of the trunk; if the forearm be brought across the chest, the lower fragment will be rotated upon its vertical axis with regard to the upper.

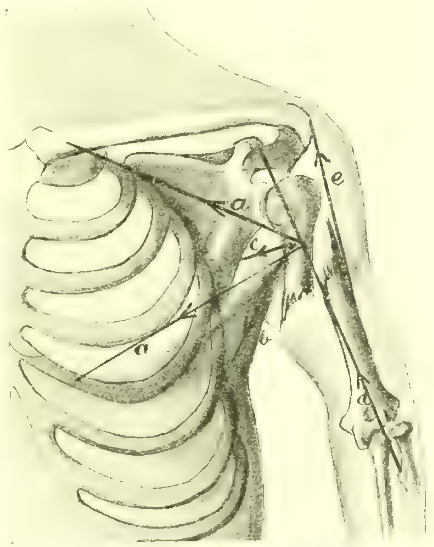


FIG. 151.—FRACTURE OF THE HUMERUS ABOVE THE INSERTION OF THE DELTOID. To show the line of action of the muscles. *a*, Pectoralis major; *b*, latissimus dorsi; *c*, teres major; *d*, biceps; *e*, deltoid.

The splints should be kept on for about four or five weeks because of the liability to non-union already mentioned, but the shoulder-cap and angular splint should be removed daily after the first fortnight, so as to carry out passive movements of the elbow and shoulder-joints. During the manipulations the fracture should be carefully steadied with one hand.

If the fracture be oblique, there is a great tendency for the fragments to over-ride, and it is well to have a radiogram taken (without removing the splints) as soon as possible after the fracture has been reduced, so as to

see whether the ends of the bones remain in proper position. If there be any serious over-riding, the fracture should be cut down upon and the bones fastened together. The incision will vary with the position and the direction of the fracture, which can always be ascertained with great exactitude by means of a stereoscopic radiogram ; it will generally be vertical, but, if preferred, a flap may be raised on the outer side of the arm. After the soft parts have been divided, the triceps is separated from the brachialis anticus and the deltoid, and the fractured ends are

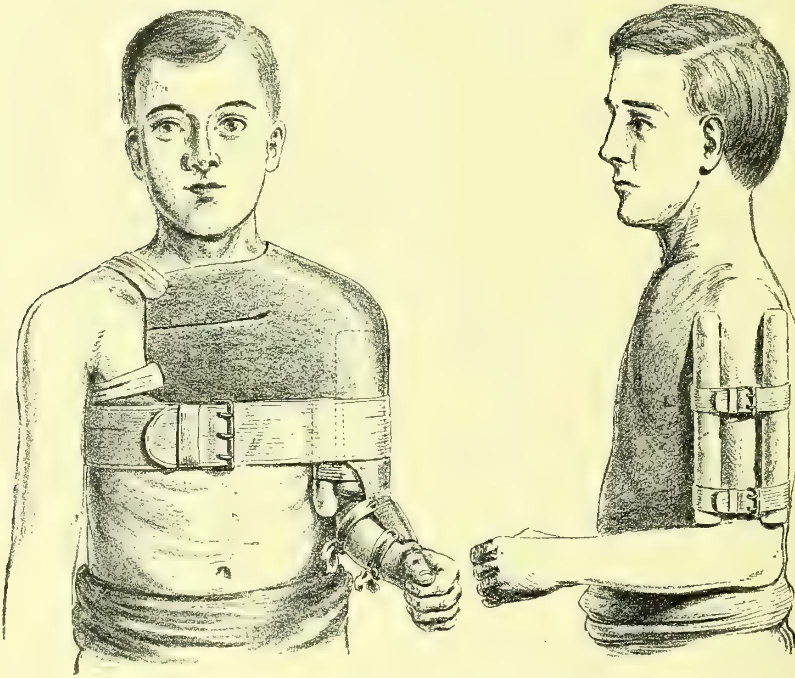


FIG. 152.—APPARATUS FOR FRACTURES OF THE SHAFT OF THE HUMERUS. In the right-hand figure is seen the first stage : anterior, posterior, and internal straight splints are applied. In the left-hand figure a shoulder-cap, prolonged downwards into an external angular splint, has been put on over these. The forearm is shown with its long axis parallel to the antero-posterior plane of the body. The apparatus is completed by a wrist-sling.

exposed, got into position and fastened together, preferably by one or two of Lane's plates. Care must be taken to avoid damage to the musculo-spiral nerve. The limb is put up as for a simple fracture.

Injury to the Musculo-spiral Nerve.—When there is evidence of injury to the musculo-spiral nerve at the time of the accident, and when no sign of recovery is apparent in the course of a few days, the fracture should be exposed and the condition of the nerve ascertained. If the latter be torn, the divided ends should be brought together and sutured (see p. 117) ; if it be merely bruised and the sheath distended with blood, the

latter should be evacuated through a vertical slit in the sheath, or, if badly pulped, the injured part should be excised and primary nerve suture employed to unite the ends. When the fracture has to be exposed for this purpose, the surgeon should fasten the fragments together.

When the nerve becomes involved in the callus, it is necessary to cut down upon it without delay, as otherwise extensive and permanent degeneration may occur. The nerve is exposed by means of the incision recommended on p. 140, traced to the seat of fracture, and its relation to this ascertained. Any mass of callus surrounding the nerve should be carefully chipped away, the greatest care being taken to avoid damaging the nerve in the process. Some of the fibres of the triceps should be stitched beneath the nerve to prevent pressure from fresh callus. If the nerve be simply stretched over a mass of callus, enough should be chiselled away to remove all chance of pressure.

FRACTURES OF THE LOWER END OF THE HUMERUS.

Fractures are fairly common in this situation and are generally produced by indirect violence, such as falls upon the outstretched hand. They may also occur from direct violence and then usually result from falls upon the elbow. These injuries are of great importance, chiefly because they often lead to considerable interference with the movement of the elbow-joint, and it depends largely on the method of treatment adopted whether the patient is left with a stiff elbow or a useful one.

SUPRA-CONDYLOID FRACTURE.

This is, perhaps, the most common fracture about the lower end of the bone. The fracture runs across the humerus just above the joint ; its line may be somewhat irregular, but it is always oblique, usually from above downwards and forwards. The forearm and elbow are carried upwards and backwards by the force producing the fracture, and the lower fragment goes with them, being drawn up behind so that the lower end of the upper fragment lies in front of the elbow, generally more or less closely in contact with the ulna. The lower fragment is also bent somewhat forwards. The result is that the fracture cannot be properly reduced by traction on the forearm owing to the flexion of the lower fragment, and unless reduction be effected, the movements of the elbow-joint are greatly interfered with. Some power of extension may be retained, but flexion beyond or even up to a right angle is practically lost.

TREATMENT.—This fracture should always be reduced under full anæsthesia. Although reduction is effected fairly easily by flexing the elbow to a right angle and then making extension with one hand, whilst the fragments are manipulated into position with the other, recurrence

of the deformity is very apt to occur if the limb be put up in this position, owing to the obliquity of the fracture. Evidence obtained by means of radiography is steadily accumulating to show that the fully-flexed position is the only one that is likely to maintain the fragments in good position. Our experience, gained largely under the X-ray screen, is that the quickest and best way of securing good coaptation is to supinate the forearm fully and then flex the elbow as far as it will go. The point of the elbow will thus be pulled forward, and the lower end of the upper fragment pushed backwards. In order to maintain the flexed position, Croft's splint, reaching from the upper third of the arm to the lower third of the forearm, should be put on the posterior aspect of the limb, and if necessary this may be strengthened opposite the elbow by pieces of block tin or strands of tow impregnated with plaster incorporated in the splint ; this splint is better than one of gutta-percha or poroplastic material. The elbow and forearm should be supported by a large sling and fastened to the side.

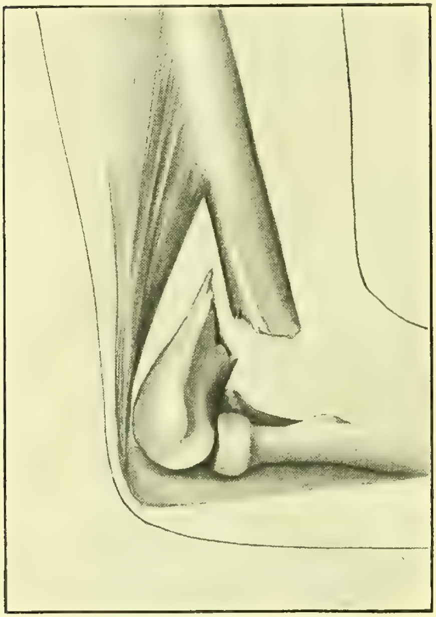


Fig. 153.—Fracture of the Lower End of the Humerus. The so-called supra-condyloid variety.

In children it is usually possible to dispense with splints altogether. When the fracture has been reduced, the arm is fully flexed so that the hand on the affected side rests upon the opposite shoulder, and the elbow is carried well forward on the chest. In the majority of cases it will be found that this position keeps the fragments in position, and if this be so, the forearm should be bandaged to the upper arm by figure-of-eight turns (see Fig. 154). Before doing this the arm should be dried and powdered so as to protect the skin, and it is well to put a fold of boric lint into the crease at the elbow-joint to absorb the perspiration and to keep the parts dry. When this bandage has been applied the part should be carefully examined to see that the reduction is maintained and, if possible, a radiogram taken. The arm is then bandaged to the chest wall in the position already described.

It is very important to ascertain by means of a radiogram, after the lapse of two or three days, whether the bones remain in good position. If this be the case, the splint may be removed at the end of a week, and

the wrist slung up close beneath the chin. This keeps the elbow still in the fully-flexed position. It is kept in this position for a fortnight, when passive movement is begun, the acuteness of the flexion being diminished a little by altering the length of the sling.

In performing passive movement, the surgeon grasps the elbow with one hand and with the other flexes, extends, pronates and supinates the forearm to its full extent. This should be done once only and only once a day. Massage may be usefully practised from the first, and may be done twice or thrice daily.

Union generally occurs rapidly, and with reasonable care there is

A *B*

FIG. 154.—METHODS OF PUTTING UP SUPRA-CONDYLOID FRACTURES OF THE HUMERUS. *A*, the flexed position; *B*, the bandage applied.

no danger of disturbing the fragments. Usually a prolonged period of massage is required, as not only do adhesions occur in the joint, but a considerable mass of callus is thrown out, which for a time interferes mechanically with movement, but which gradually becomes absorbed.

Flexion must be maintained for at least three weeks and is then gradually diminished. The object of this is to prevent the formation of callus in the coronoid fossa. Callus may form in the olecranon fossa and lead to some limitation of extension, but this is of less importance than limitation of flexion. An arm that can be moved from full flexion to a little beyond the right angle is a serviceable limb, whereas movement from full extension up to a right angle means a comparatively useless

one. If the limb can be used, constant voluntary movements will increase the range of movement, but if the limb is not serviceable, the full extent of movement may never be regained.

SEPARATION OF THE LOWER EPIPHYSIS.

In young subjects this may take the place of the fracture just described. These cases are rarely simple separations of the epiphysis, as usually the line of fracture, like the one just mentioned, extends obliquely upwards and backwards. The displacement is similar to that in the supra-condyloid fracture.

TREATMENT.—The epiphysis is generally easily reduced and maintained in position. The limb should be put up and treated as a supra-condyloid fracture. The ultimate results are usually satisfactory.

T-SHAPED FRACTURE INTO THE JOINT.

There may be a vertical fracture of the lower fragment into the joint, in addition to the supra-condyloid fracture described above; this is spoken of as a T-shaped fracture of the lower end of the humerus. The direction of this vertical fracture varies; sometimes it is oblique, but usually it enters the joint between the two condyles.

This fracture is of the highest practical importance, because it is a comminuted fracture of the lower end of the humerus, and in it there is not only backward displacement of the fragments as a whole, but the two portions into which the lower fragment is split up are displaced on one another and the consequence is that little or no movement in the elbow-joint may result, unless perfect reduction has been obtained and maintained. The conformation of the elbow-joint is such that very slight irregularity of the articular surfaces is sufficient to interfere with movement to a very serious degree.

TREATMENT.—The treatment here is much more difficult than in the supra-condyloid fractures, and the best chance of getting a good result is by operative interference. In adults the best plan is to cut down upon the fracture and fasten the broken ends in position. In young children the fragments are often so small and friable that no wire or screw will hold, and in these cases the fragments, after being exposed, are manipulated into position, and then, if it is impossible to secure them by driving in tacks or fine pins, the arm is put up in the flexed position and treated as for a supra-condyloid fracture.

Before proceeding to operate, the fullest information as to the size, shape, and position of the fragments should be obtained by means of stereoscopic radiograms. The fracture is best reached by a free lateral incision over each condyle, but the tissues must not be detached too freely from either condyle, as otherwise the nutrition of the fragments might be

interfered with. When one or both fragments are small, it will be better to cut down in the middle line behind, split the triceps, peel it off from the olecranon to a slight extent without cutting it across, and so gain access to the fracture without unduly denuding the condyles. Any small loose fragments are removed, and all blood-clot is cleared out from the articular cavity. The fractured condyles are then fastened together. When a median vertical incision has been employed, a small lateral incision should be made over one condyle in order to allow of the introduction of a drill which is made to perforate the condyles transversely from side to side, while the fragments are held in accurate apposition. When lateral incisions are used, the drill can be passed through one of them.

Fig. 155.—Comminuted Fracture of the Lower End of the Humerus. This is a good example of how difficult it may be to get perfect apposition of the fragments.

Into the drill hole is driven either a steel pin, the end of which projects from the opening to permit of its subsequent removal, or a fine square ivory peg, which may be cut short and left in. Through the posterior incision the condyles, thus united to one another, should be fastened to the shaft of the bone by screws, plates or wires. The steps of the operation vary according to the circumstances of each individual case, and cannot be described in full detail. Sometimes the line of fracture is such that the best hold will be obtained by fastening each condyle separately to the shaft without joining them to each other first. The question as to whether lateral incisions or the median vertical incision should be employed will depend upon which will give the easiest access to the fracture. Generally the median incision is the best.

The wound is sewn up without a drainage tube, and the limb is put up in a Croft's splint in the fully-flexed position. The subsequent treatment is the same as for a case of supra-condyloid fracture (see p. 332). If a metal pin has been inserted it may be removed about the end of the third week, but there is no reason why massage should not be carried out without reference to it, provided that a piece of gauze soaked in a 1 in 2000 sublimate solution be wrapped around the end of the pin and the skin wound during its performance.

FRACTURE OF EITHER CONDYLE ALONE.

Either condyle may be fractured, the line of fracture starting above the condyle and running obliquely downwards into the elbow-joint between the condyles. There is generally displacement forwards of the broken fragment, which is very difficult to overcome; serious interference with the movements of the joint may result unless the fracture is accurately set.

TREATMENT.—The surgeon may either manipulate the fragments into position under an anæsthetic and then put up the limb in the position recommended for supra-condyloid fracture, or he may cut down and fasten them in position. The latter is the better method, for a slight irregularity in the joint surfaces may lead to serious disability.

We, therefore, recommend that operation should be undertaken without loss of time. An incision is made over the fractured condyle, and the soft parts are turned back until the line of fracture is exposed. All blood-clot is cleared out, and any loose bone removed, and the fragments are then coapted and held in position by an assistant, while the surgeon runs a drill across the lower end of the humerus from one condyle to the other transversely to the long axis of the bone. In doing this, care must be taken not to encroach upon either the olecranon or coronoid fossa. A square ivory peg, a steel pin, or a screw is then inserted. The subsequent treatment is the same as that given on p. 333.

FRACUTRE OF THE INTERNAL EPICONDYLE.

The internal epicondyle may be broken off by direct violence, and the detached fragment is usually pulled forwards and downwards by the muscles attached to it. The resulting disability is not great because the displacement is usually slight, but if the separation be marked there may be considerable loss of power.

TREATMENT.—This fracture is outside the joint, and it is generally sufficient to put the arm up in the fully-flexed position so as to relax the flexor muscles; an attempt may be made to press the fractured portion of bone back into position by means of a suitable pad and strapping. If, however, there be any difficulty in getting the fragment back into place, it is easy to expose the tip of the condyle and fasten it in position by a plate or screw.

CHAPTER XVII.

FRACTURES OF THE FOREARM AND HAND

FRACTURES OF THE OLECRANON.

THIS accident is generally caused by direct violence from falls upon the point of the elbow, the olecranon coming into violent contact with the ground. It may occur, however, from muscular action alone, the olecranon being snapped off by the sudden contraction of the triceps when the arm is bent at right angles. The fracture usually occurs near the base of the process, but in some cases the tip alone may be broken off, while in others the fracture runs obliquely from below upwards and forwards into the joint near the front of the greater sigmoid cavity.

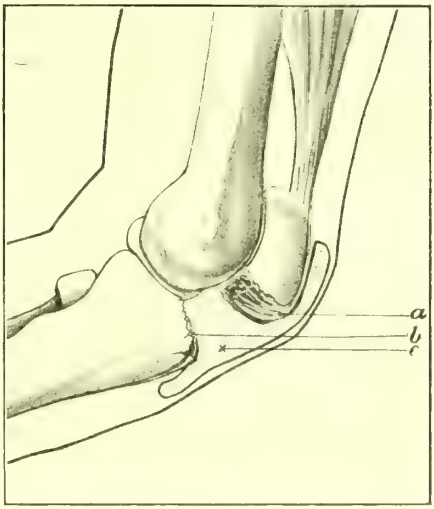


FIG. 156.—DIAGRAM INDICATING THE CONDITION OF THE PARTS IN A FRACTURE OF THE OLECRANON. *a*, The torn fascia turned in over the upper fragment; *b*, ditto over the lower fragment; *c*, bursa torn open and filled with blood.

The process is generally separated completely, but the fibrous expansion of the triceps and anconeus muscles over the back of the bone may remain intact, and then only slight separation of the fragments occurs. When the tip of the olecranon is broken off and the fascia is torn, the small piece of bone is often drawn up the arm for a considerable distance. In fractures in the usual situation, near the base of the process, the amount of separation depends upon how far the fibrous tissues are intact; in those still lower down, in which a part of the curved articular surface of the ulna remains in

connection with the olecranon, the separation is not marked, particularly when the forearm is extended, as the curved articular surface prevents displacement upwards. In any case, however, the separation of the fragments is increased when the elbow is flexed.

Fracture of the olecranon is always accompanied by inability to extend the forearm fully. When bony union does not take place, the patient may be unable to throw, to forcibly extend the arm, or to carry heavy weights. In fact, even when the separation is not great, the limb is feebler than its fellow; its range of movement is also frequently hampered by the presence of adhesions in the joint. Hence it is important to obtain bony union if possible; in the majority of cases treated by apparatus, union occurs only by fibrous tissue, which is apt to stretch afterwards and lead to progressive impairment of function.

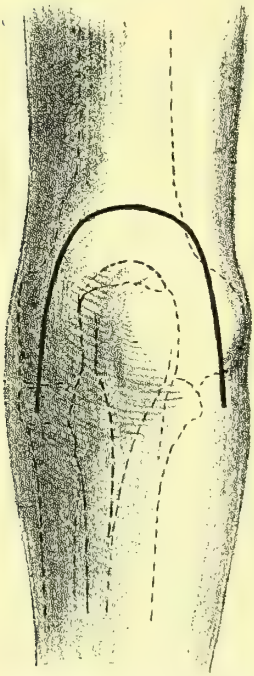


FIG. 157. — INCISION FOR WIRING THE OLECRANON. The dotted lines indicate the outline of the bones.

TREATMENT.—**In Recent Cases.**—In all cases except those in which there is little or no separation of the fragments the best treatment is to cut down on the fracture as soon as possible, to remove any structures interposed between the fragments, and then to fasten them together.

Operative.—The elbow-joint is semi-flexed and the forearm is carried across the chest, while the surgeon stands upon the affected side. The limb may be extended while the flap is being marked out, but access to the joint in the subsequent stages is facilitated by semi-flexion

The incision should be crescentic, with its convexity upwards; a straight one does not give such free access to the fracture, and it has the further disadvantage that the wire is apt afterwards to penetrate the thin scar which then lies directly over it, and, should re-fracture occur, the scar is liable to give way and lead to a compound fracture. The incision should begin and end close beside the olecranon just below the line of fracture, and its convexity should reach up to about an inch above the tip of the process (see Fig. 157). It is of no real importance whether the incision be made as above and a flap thrown down, or whether a flap be turned up by making an incision with its convexity downwards on the forearm reaching well below the line of fracture. In recent cases the one described above is perhaps preferable, as the cicatrix does not lie over a subcutaneous bone surface anywhere. In long-standing cases,

however, where there is great separation, it may be advisable to turn the flap upwards because it is then easy to prolong the ends of the incision up along the back of the arm, if it should be necessary to lengthen the triceps (see p. 344). A flap consisting of skin and fascia only is turned down, and when the fracture is reached the gap between the fragments is evident at once. If the rent in the deep fascia be incomplete, it is well to enlarge it, and if its torn edges be inverted over the fractured surfaces, they must be turned out of the way; all clots are removed from the

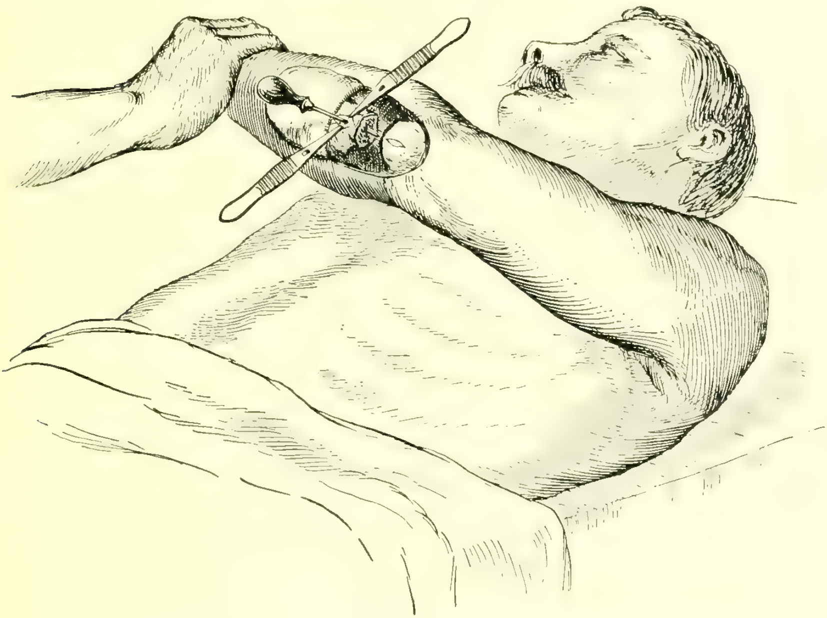


FIG. 158.—OPERATION FOR WIRING THE OLECRANON. *Drilling the bone.* The catch-forceps are shown in position on either side of the vertical incision through the periosteum, the edges of which they hold apart as the drill is passed. The point of the drill is seen emerging just behind the articular cartilage. A vertical slit has been made in the soft parts over the fractured process, which has not yet been drilled.

joint before the fractured ends are fastened together. The fixation of the fragments may be effected by means of a plate (see p. 307) if desired, but upon the whole we have found wiring preferable.

Wiring is done as follows: A median vertical incision a quarter of an inch long is made through the periosteum of the ulna about half an inch below the line of fracture, and, before the knife is removed, the two edges of this incision are seized with catch-forceps and held apart, so as to expose the bone beneath (see Fig. 158). A hole is then bored obliquely through the bone with a bradawl, the point emerging on the fractured surface just behind the articular cartilage. After having ascertained the spot on the upper fragment exactly corresponding to this puncture by

pushing the fractured ends together, the bradawl is withdrawn, a vertical median incision is made through the periosteum over the upper fragment

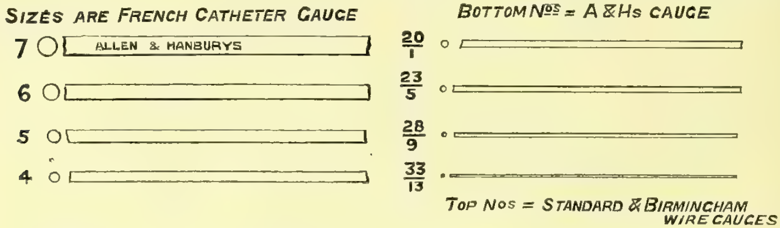


FIG. 159.—WIRE GAUGES. Those on the left are used for wiring bones like the patella, femur, tibia, etc. Those on the right are the standard wire gauges.

about half an inch above the line of fracture, and its edges are seized with forceps as before. The bradawl is then introduced obliquely through the

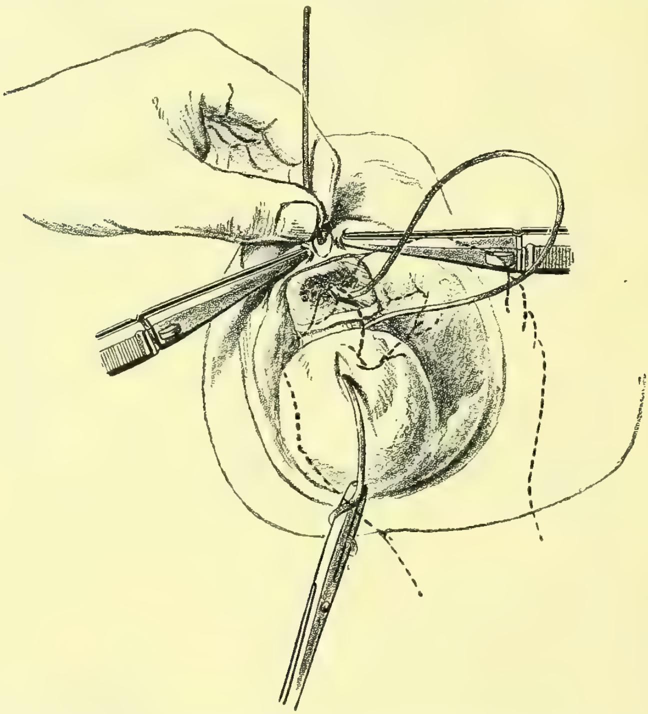


FIG. 160.—OPERATION FOR WIRING THE OLECRANON. *Method of passing the wires.* The elbow is fully flexed to increase the space between the fragments. After the wire has been passed through the hole in the detached process, a long loop is pulled out, and the end of the loop is pushed through the hole in the base of the olecranon from the fractured surface. The catch-forceps are in position, as in the preceding figure; those on the detached process have been taken off after the passage of the wire. The hand is put in in dotted outline in order to render the detail more clear.

bone here, and made to appear on the fractured surface exactly opposite the hole previously made through the base of the process. A silver wire

about a twentieth of an inch in diameter (No. 20 Birmingham wire gauge) is then pushed through the hole on the posterior surface of the fractured process, and a good length of it is pulled out between the fractured surfaces; this is bent into a loop so as to allow the end to be pushed through the corresponding hole on the opposite fractured surface, and thence out of the aperture at the base of the process (see Fig. 160). The passage of the wire can be facilitated by filing the end to a blunt conical point before sterilising; when a wire has been cut across with scissors, sharp edges are left which may catch in the fascia and impede its passage.

During the passage of the wire the edges of the slits in the periosteum

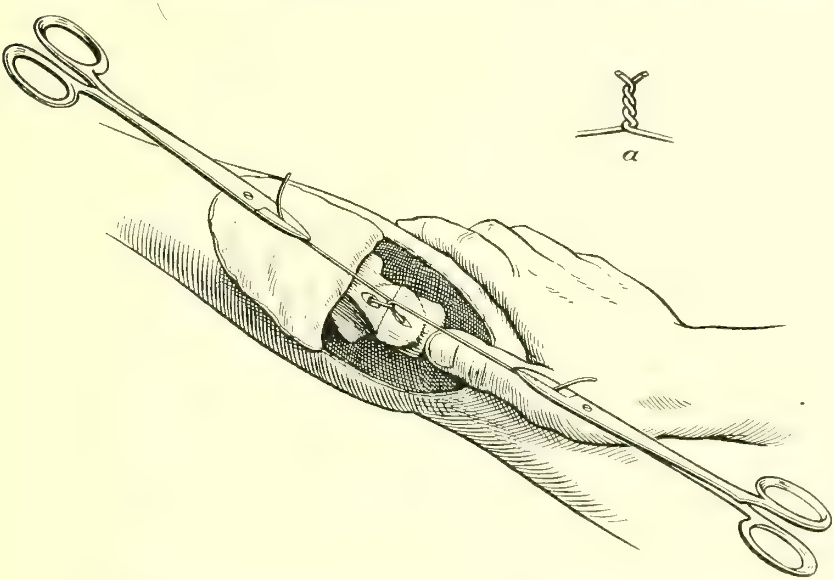


Fig. 161.—Operation for Wiring the Olecranon. *Twisting the wire.* The figure shows the elbow-joint extended fully and the fractured process pushed down in place by an assistant as the wire is twisted; *a* shows the correct method of twisting the wire.

and fascia made before introducing the bradawl are held aside by the catch-forceps, otherwise, on attempting to introduce the wire through the first hole, it may be difficult to find the aperture in the bone, and when the end emerges from the second hole it may become entangled in the fascia and may be pushed down the arm for some distance. During the passage of the wire the elbow is fully flexed, so as to increase the gap between the fragments and give more room for the manipulations when the wire has been introduced.

When the wire has been passed, the elbow is extended, and the wire pulled straight by grasping the ends in forceps and exerting traction; an assistant pushes the fractured surfaces together and the wire is then bent round and twisted several times (see Fig. 161). No attempt should be made to force the fragments together by traction on the wire; this

is ineffectual as a method of tightening it up, and causes the wire to cut through the bone. The wire is cut off short and the ends are hammered down on to the bones with a small tack-hammer, so as to bury them completely in the fascia. The wound is sutured without a drainage tube and a considerable mass of dressing is put on, so that it shall restrict the movements of the joint; the limb is put up with the elbow flexed almost to a right angle. The wire will prevent any separation of the fragments, and the rectangular position is better than the straight as far as the subsequent movement is concerned. No splint is necessary; the arm is placed in a sling, and the patient is allowed to move the elbow-joint if he desires to do so. There is no risk of his moving the limb to such an extent as to interfere with the healing of the wound.

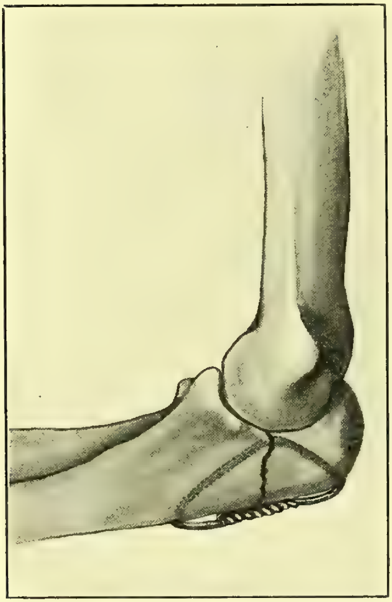


Fig. 162.—A Fractured Olecranon united by a Wire. To show the exact position that the wire occupies.

After-treatment. — The dressing should be left untouched for a week or ten days when the stitches are removed and a collodion dressing is applied. The arm is replaced in the sling, but before doing so it is well to employ a little passive movement. As a general rule, no adhesions of any consequence will be found. After the lapse of another two or three days the patient may be allowed to dress, to put the arm into a sleeve, to move it for purposes of feeding and so forth, and, although he should be enjoined not to lift or move heavy weights, no marked restriction need be placed on its use; three weeks after the injury the arm is generally as useful as it was before. Of course at this time there is no firm bony union but the wire does not yield, and bony union occurs in spite of the movement of the joint. In this way adhesions are avoided, and there is no necessity for forcible movements and massage later on. We attach much importance to the method of putting up the limb in a large mass of dressing without any splint. Adhesions are very apt to form if a splint be used, and these may give rise to considerable difficulty in the after-treatment, as they may require considerable force to break them down and a re-fracture is not at all unlikely to result.

Palliative.—When there is only slight separation of the fragments (*vide supra*), when some grave constitutional disease, such as diabetes, renders operative interference a serious matter, or when the patient

is very old or declines an operation, some form of mechanical apparatus must take the place of operative interference. Should a radiogram show that the fracture is starred or comminuted, as it sometimes is, it will also be better to employ apparatus. The simplest is a straight splint along the front of the arm and forearm, with a pad in the bend of the elbow, so that the arm is not fully extended; otherwise the position becomes so irksome that the patient insists on discarding the apparatus. An attempt should be made to bring the upper fragment into contact with the lower by strapping. The arm is abducted to a right angle, and narrow strips of strapping are applied with their centre above the fragment (over which is placed a small pad of boric lint), and the ends are brought obliquely downwards to the sides of the splint below the elbow; it is well to make a small notch in the splint on either side to prevent the strapping from slipping. By this means the two fragments may be kept in apposition for a time if there is not much separation. The strapping will require daily inspection and frequent renewal. If there be much effusion into the joint—as there often is in cases not operated upon—an ice-bag or a Leiter's coil may be applied over the point of the elbow.

After-treatment.—The chance of bony union is comparatively slight. The limb should be kept in the extended position for about six weeks; it must be taken off the splint from time to time, so as to allow of passive movements being carried out. When the elbow is flexed, the upper fragment must be carefully fixed and pressed downwards in contact with the lower. There is often considerable stiffness left, in spite of the passive movement, and this is partly due to adhesions in the joint and partly to some irregularity in the cartilaginous surfaces of the bone, or to some contraction of the triceps. It may be necessary to employ an anæsthetic to break down these adhesions; the greatest care must be exercised to avoid tearing through the weak ligamentous union between the fragments.

In Old Cases.—When a case has not been operated upon, the fibrous tissue between the fragments not infrequently becomes so stretched that there is no really effective union; these may be looked upon as ununited fractures. The patient may consequently suffer considerable disability, especially if he has to earn his living by manual labour, and if the right arm is affected, he often applies for relief. The only effectual treatment is by operation, but favourable results are much more difficult to obtain than in recent fractures.

Operation.—A flap is raised by an incision (see p. 338) with its convexity downwards, and its extremities carried up the arm some distance until the upper fragment with the tendinous and muscular tissues inserted into it is exposed. The fibrous material between the fractured surfaces is cut away, and then the joint should be flexed and extended to the full extent in order to break down adhesions. The ends of the bones are next refreshed by removing a thin slice from each with a saw or chisel, until the whole area of the fracture shows

cancellous bone. An attempt is now made to approximate the fragments. As a rule it is difficult to bring down the upper fragment into contact with the lower, and in some cases it is impossible to do so without dividing the triceps. This is done as follows:

Lengthening the Triceps.—If the muscle be divided transversely a gap will be left in it, which may cause much functional disability. The incision should, therefore, be V-shaped or zigzag and carried through the breadth of the muscle (see Fig. 163); two V's or serrations, with their apices upwards, are usually sufficient. The incision commences at the left edge of the triceps and is carried obliquely upwards and to the right through the muscle for about two inches, according to the amount of shortening present, and terminates at a distance from the left edge equal to one quarter the entire breadth of the muscle. From this point a second incision is carried obliquely downwards and to the right, terminating in the centre of the muscle on a level with the starting-point of the first. A third incision then runs obliquely upwards, and also to the right terminating at the three-quarter point, and the division is completed by carrying another from this point obliquely downwards to the right again, and bringing it out through the right edge of the muscle. This gives a series of serrations above and below the line of incision, and when the fragment with the tendon attached to it is pulled down, the apices of the serrations should be in contact if the incision has been planned properly. The adjacent sides of the serrations above and below are stitched together, so that a blunt cone is formed above and another below the line of division of the muscle; the apices of these blunt cones are then stitched together by the muscle suture described on p. 64. The incision should be made in the lower part of the muscle, so that the apices of the upper serrations include some portion of the tendinous expansion. The best union is obtained when muscular fibres are included in the incisions instead of making the latter entirely through the tendon.

FIG. 163.—METHOD OF LENGTHENING THE TRICEPS IN THE OPERATION FOR WIRING LONG-STANDING CASES OF FRACTURE OF THE OLECRANON. The figure shows the long flap required for the exposure of the Triceps, and the serrated division of the muscle described in the text. The apices of the serrations are made blunt in order to secure a larger surface for union.

When the fragment has been brought down by this means, it is drilled and the wire passed as already described (see p. 339). The bone,

and especially the detached fragment, is often much softer than in recent fractures, and the holes must be bored as far as possible from the fractured surfaces, so as to get a firm hold, otherwise the wires may cut out.

After-treatment.—This is similar to that described for recent fractures, but greater caution must be exercised in carrying out movement, because of the softness of the bone ; it is also well to put on a splint for a few days. At first the limb should be put up almost straight, but every third day a slight increase in the flexion may be made. As soon as the arm has been brought to a right angle, the splint may be abandoned and a sling substituted. In about a fortnight after the operation, the patient may be allowed to move the arm to some extent ; flexion beyond a right angle should be delayed until bony union has occurred, as otherwise the wire may cut through the soft bone.

The difficulty in getting a useful arm in cases of ununited fracture serves to emphasise the necessity for immediate operation in recent cases, provided that the surgeon can trust his antiseptic precautions ; should suppuration occur the result is likely to be disastrous. All that can then be done, under such circumstances, is to remove most of the stitches, take out the wire, insert a drainage tube, and thoroughly drain the joint.

FRACTURE OF THE CORONOID PROCESS.

Fractures of the coronoid process practically only occur in connection with dislocation of both bones of the forearm backwards. An important point in the diagnosis is that, while the dislocation is easily reduced, the deformity recurs immediately. The loose fragment of the coronoid may interfere with flexion of the limb. A radiogram will make the nature of the condition clear.

TREATMENT.—The treatment is very difficult, for union practically always takes place by fibrous tissue. The best plan is to flex the joint fully after correcting the backward dislocation ; this relaxes the brachialis anticus and brings the broken surfaces as nearly as possible into contact. A pad is applied over the olecranon, and then a poroplastic splint should be moulded to the posterior aspect of the limb while it is in the flexed position. Passive motion should be begun in a fortnight and practised daily for five weeks, when all apparatus may be left off.

This injury only gives rise to marked disability when so much callus is thrown out as to form an obstacle to flexion. Occasionally ossification extends upwards in the tendon of the branchialis anticus, and a spurlike process is formed which greatly hampers movement, and may necessitate removal of the offending portion of bone. The best access to the bone is then obtained by lateral incisions, one on either side of the joint, just over or slightly in front of the condyles of the humerus, avoiding the median and the musculo-spiral nerves. The soft parts are peeled off the condyles and pulled forwards from the front of the joint so as to

expose the branchialis anticus with the coronoid process embedded in it the mass of bone may then be shelled out. It is not easy to perform this operation satisfactorily through a single incision ; the external incision greatly facilitates matters, because the finger pushed through it can displace muscle and its tendon to the inner side and render them much more accessible. The connection between the muscle and the base of the coronoid process is not disturbed in this operation, and, therefore, the full power of flexion should be regained. When there is bony union with exuberant callus, the latter must be chipped off and removed.

FRACTURES OF THE HEAD AND NECK OF THE RADIUS.

Fractures in this situation are rare, but of great importance ; they usually result either from direct violence or from injuries occurring in connection with dislocation. In young children a fall upon the hand may produce dislocation of tne radius or separation of its upper epiphysis. In adults the injury is generally caused by a direct blow on the outer side of the arm, and we have seen cases of vertical fracture of the head of the radius with detachment of a portion of the head, which was lying free in the elbow-joint. In this accident there is little chance of getting union, while the loose fragment causes a mechanical obstruction to movement and leads to pain, irritation, and the formation of adhesions. The diagnosis is materially facilitated by the use of radiography.

Fig. 164.—Incision for Excision of the Head of the Radius. The continuous line indicates the skin incision, the broken one the intermuscular septum through which the bone is exposed. This is an alternative method to the one described in the text.

TREATMENT.—The detached fragment should be removed as soon as possible. The best method of gaining access to the head of the radius is by an incision on the posterior and outer surface of the elbow close behind the outer condyle of the humerus. It should commence just above the external condyle and run downwards and a little backwards towards the posterior border of the ulna for about three inches. This incision will lie between the triceps and the radial extensors of the forearm above, and over the interval between the extensor carpi ulnaris and the anconeus below. When the two latter muscles are separated, the capsule

over the head of the radius is exposed and opened by a horizontal incision and the detached portion of the head of the radius removed. If a considerable portion of the articular surface of the radius be intact, there is no need to take this away; the detached portion should be removed and the wound in the joint sutured. If, however, the portion remaining attached to the shaft be very small, it is best to clip it away and thus to excise the head of the radius. The slight shortening that occurs does not in any way interfere with the movements of the arm. The incision in the capsule is sutured with fine catgut, and the skin wound stitched up without a drainage tube.

After-treatment—The after-treatment will be similar to that already described for fracture of the olecranon (see p. 342); passive movements must be resorted to early and maintained persistently.

When the epiphysis has been separated the arm should be put up in the position of full supination upon an anterior angular splint; a straight splint should also be applied along the back of the forearm, and passive movement should be carried out after the first fortnight.

FRACTURES OF THE MIDDLE OF THE FOREARM.

Either bone of the forearm may be fractured separately, or fracture of both bones may occur simultaneously.

FRACTURE OF THE ULNA ALONE.

This injury is comparatively rare and is generally due to direct violence. The displacement depends to a great extent on the direction of the force and the situation of the fracture, and may not be at all marked. The upper fragment is often tilted forwards by the brachialis anticus, while the lower one is pulled outwards towards the radius by the pronator quadratus. The subcutaneous position of the bone allows the displacement to be made out readily by manipulation.

Fracture of the ulna may be complicated with dislocation of the head of the radius. When this happens, the usual condition is a fracture of the ulna at the junction of the upper with the middle third and a forward dislocation of the head of the radius. A stereoscopic radiogram will show the exact state of affairs.

TREATMENT.—The treatment should be directed first to bringing the fractured ends into apposition by manipulation, which is best accomplished under an anæsthetic. The arm is then put up on an internal angular splint, with the elbow at right angles, and the forearm midway between pronation and supination. More comfortable than the ordinary wooden splint is a moulded one of poroplastic material which partly encircles the arm and holds the forearm in position; the fingers should be left out and should be actively exercised. Early massage and

movement should be employed (see p. 280) and the splint may be given up entirely in four weeks.

When there is also Dislocation of the Head of the Radius.—*In recent cases* reduction of the dislocation is readily effected under an anæsthetic. The head of the radius can be pulled into place by simple extension, and at the same time the fractured ends of the ulna are manipulated into position. The forearm should be put up in a moulded splint in the supinated position with the elbow at a right angle, and a pad is placed in front of the head of the radius to prevent recurrence of the dislocation. Passive movement, especially rotation, should be begun within the first fortnight.

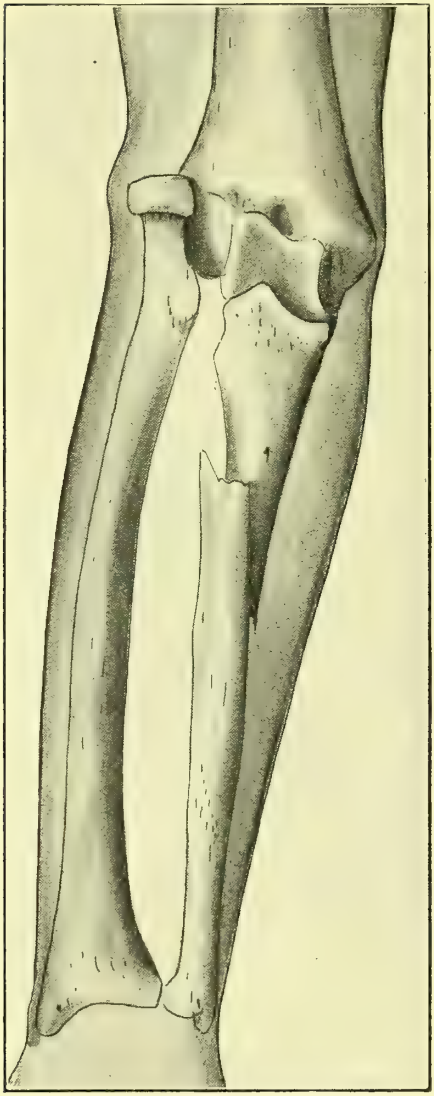


Fig. 165.—Fracture of the Ulna with Dislocation of the Head of the Radius.

In long-standing cases of dislocation of the radius, it is usually necessary not only to cut down and divide the fracture of the ulna, but to remove the head of the radius. It is sometimes possible to get the head of the radius into position after dividing the fractured ulna, but, if not, the loss of the head of the radius does not materially affect the movement of the elbow-joint. For the method of exposing the head of the radius, see p. 346. Access to the fracture of the ulna will be got by cutting down directly on it posteriorly.

FRACTURE OF THE RADIUS ALONE.

This fracture is generally due to indirect violence, such as a fall upon the hand, and is much commoner than fracture of the ulna alone.

The displacement varies according as the fracture is above or below

the insertion of the pronator radii teres muscle. In the former variety the upper fragment will be fully supinated by the biceps and the supinator brevis muscles, and also somewhat flexed by the former. The lower fragment will be pronated by the two pronator muscles, and drawn inwards towards the ulna. If, however, the fracture be below the insertion of the pronator radii teres, the upper fragment will be midway

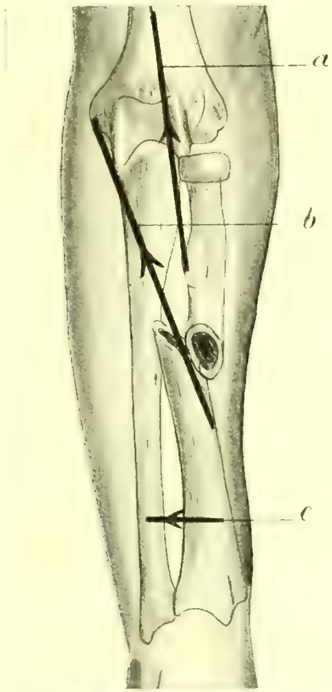


FIG. 166.—FRACTURE OF THE RADIUS ABOVE THE INSERTION OF THE PRONATOR RADII TERES. To show how the displacement is produced. *a*, line of action of the Biceps; *b*, line of action of the Pronator radii teres; *c*, line of action of the Pronator quadratus.

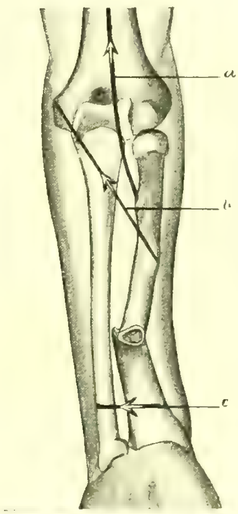


FIG. 167.—FRACTURE OF THE RADIUS BELOW THE INSERTION OF THE PRONATOR RADII TERES. To show how the displacement is produced. *a*, line of action of the Biceps; *b*, line of action of the Pronator radii teres; *c*, line of action of the Pronator quadratus.

between pronation and supination, while the lower will be completely pronated and drawn inwards towards the ulna.

TREATMENT.—*Of Fracture above the Insertion of the Pronator teres.*—The elbow must be flexed to a right angle and the forearm fully supinated. An anterior rectangular splint and a posterior straight one are applied, the latter reaching from the olecranon to the back of the hand. A pad should be placed over the lower end of the upper fragment, so as to keep it back, and the elbow and forearm should be supported by a large sling.

These splints should be kept on for about four weeks, when rotary

motion may be commenced ; passive movements of the elbow and wrist should be practised after the first fortnight.

Of Fracture below the Insertion of the Pronator teres.—The forearm should be put up at right angles in a position midway between pronation and supination. The best splint is an external angular one, moulded to the arm and forearm and surrounding the limb almost completely. It may be made of poroplastic or plaster of Paris, and should extend from the axilla above to the metacarpal bones below, but the fingers should be left free. An ordinary wooden internal angular splint with a straight splint over the posterior surface of the forearm may be used in default of a moulded one.

FRACTURE OF BOTH BONES OF THE FOREARM.

This may occur from indirect violence, as in a fall upon the outstretched hand, or from direct injury. The displacement is generally only slight and is influenced largely by the force producing the fracture. The fracture of the radius is often oblique, and there may be a good deal of over-riding of the fragments.

TREATMENT.—There are two important points to remember in the treatment of these fractures in the middle of the forearm. In the first place, it is in this situation that ununited fracture of the radius is fairly common, and this no doubt results from want of proper fixation of the elbow, the movements of pronation and supination being insufficiently guarded against. In the second place, there is a tendency for the four fractured surfaces to be drawn towards one another, and union may actually take place between them, with complete loss of pronation and supination. Non-union is avoided by fixing the forearm so that pronation and supination are impossible. Fusion of the fractured ends may be prevented by avoiding all lateral pressure on the bones after proper coaptation.

An anæsthetic should always be given before reducing the fracture ; this enables the fragments to be got into better position, and ensures their keeping in place until the splints have been applied. The next important point is the determination of the position in which the forearm shall be put up. This depends upon the situation of the fracture in the radius.

When the fracture is above the insertion of the pronator radii teres, the forearm must be fully supinated, and an anterior angular and a posterior straight splint should be applied. When the fracture is below this point, the limb should be placed midway between pronation and supination, and the moulded splint or the two straight wooden splints, recommended for fracture of the radius alone (*vide supra*), should be employed. If wooden splints be used, their width should be somewhat greater than the transverse diameter of the forearm, so that the bandage fixing them

on cannot exert lateral pressure upon the bones. At the same time the splints must not be too broad, as otherwise the arm would slip about from side to side if the bandages became loose, and thus the deformity might recur. Wooden splints should be cut to the shape of the forearm and should be wide enough to project about half an inch beyond it everywhere; hence they must be much broader above opposite the bellies of the muscles than about the wrist. The ordinary splint as supplied by instrument makers is not suitable; it must be cut to fit the arm (see Fig. 168).

It is often recommended that a pad should be applied between the bones along the middle of the forearm in front, so as to prevent union

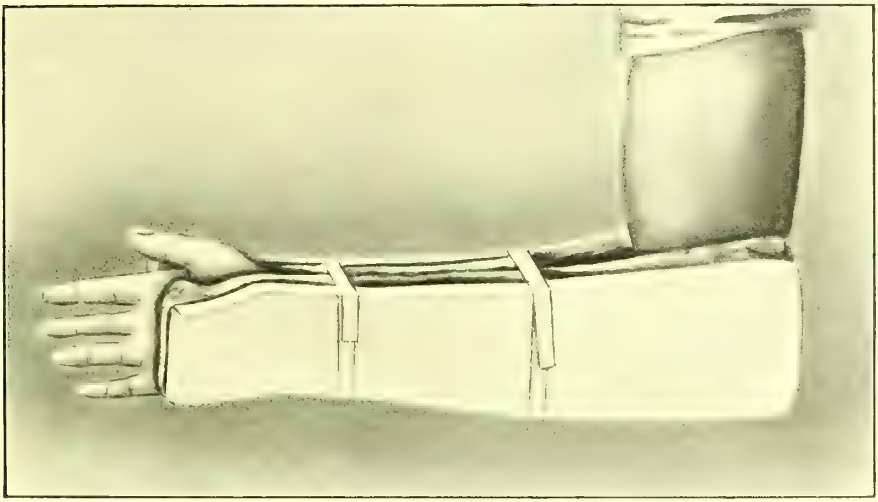


FIG. 168.—SPLINTS APPLIED FOR A FRACTURE OF BOTH BONES OF THE FOREARM.

of one bone to the other. No pad could separate the bone ends without exerting injurious pressure on the circulation. The surgeon must rely for success upon proper reduction and immobilisation of the fracture in the first instance.

This is one of the fractures in which an operation should be performed at once, if a stereoscopic radiogram shows that the position is not good. The seat of fracture should be exposed by means of lateral incisions over the radial and ulnar borders of the forearm respectively. Upon the ulnar side no important structures need be considered, but upon the radial side care must be taken to avoid the posterior interosseous nerve, and lower down the radial. The bones are best fixed by thin plates and screws (see p. 307). Before applying the plates care must be taken to see that there is no rotation of one fragment upon the other. The arm is put up midway between pronation and supination (see Fig. 168)

After-treatment.—It is as a result of putting up these fractures badly that the condition known as 'Volkmann's contracture' (see p. 294) has generally occurred, and, therefore, the greatest care must be taken to see that the pressure of the splints is not unduly severe. The splint should extend down to the transverse crease of the palm, so as to allow active and passive movement of the fingers to be practised from the first. The forearm should be placed in a sling supporting both the elbow and the hand. The splints may be left undisturbed for a week, after which they should be taken off daily in order to practise active and passive movements of the wrist and elbow-joints. The splints must not be discarded until the fifth or sixth week, and not then unless the union be firm. There is not the same risk of stiffness in the joints or about the tendon sheaths as in the fractures lower down, whilst the risk of non-union is considerable.

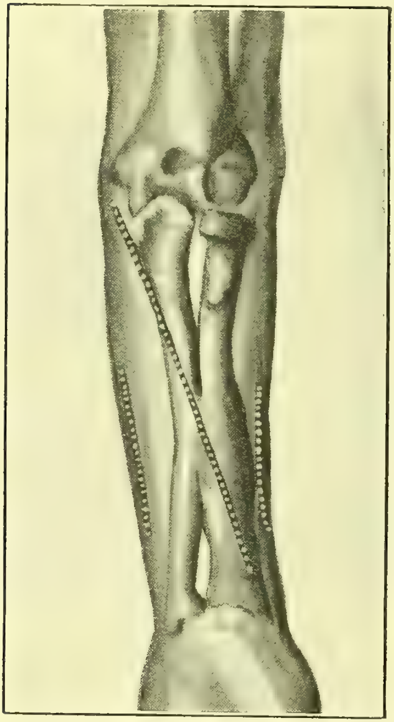


Fig. 169.—Diagram illustrating 'Cross-union' after Fracture of both Bones of the Forearm. The dotted lines indicate the incisions that may be necessary to rectify the condition.

Greenstick Fracture.—This is common in children. The treatment is similar to that just described; the bones should be forcibly straightened under an anæsthetic before the limb is put up. The splint need only be kept on for three weeks. After that the arm should be worn in a sling for another ten days.

Mal-union in Fractures of both Bones.—*When the bones have become fused together by callus* so that pronation and supination are lost, it will be necessary to expose the seat of fracture and chisel away the uniting medium so as to free the bones and restore their movements. The best route to the bones is through an anterior oblique incision in a line from the internal condyle of the humerus to the styloid process of radius over the situation of the fracture; the pronator radii teres can then be pulled upwards and the flexor muscles downwards and inwards. The incision must be free, and the muscles should be relaxed by flexing the elbow, the wrist, and the finger-joints. When the callus has been defined, the redundant portion is cut away, if possible without dividing the union between the fragments of the individual bones. Should there

be deformity, however, the union must be cut through and the position rectified. This may perhaps be done through the original incision, but it may be necessary to make additional incisions directly over the lateral aspect of the fractures, in order to get proper access (see Fig. 169). An attempt should be made to stitch some fascia or muscle over any raw surface of the bone left, so as to prevent any possibility of the bones becoming fused together again.

After the wound has healed, passive motion of the joints should be commenced at once. Unless the union has been divided at the operation, there is no necessity for keeping the limb in splints. A large sling supporting the elbow and the forearm will suffice.

In badly united fractures with marked deformity and loss of usefulness of the hand it may be necessary to expose the fracture and divide the union. Two incisions must be made, one over each side of the limb. The bones can be secured by wires (see Fig. 306), or by the plates recommended for ununited fractures (see p. 307).

Ununited Fracture.—To secure union in ununited fractures of the forearm an operation is necessary, and the best access to the bones may be got through longitudinal incisions over the outer and inner borders of the forearm. When the bone has been ununited for some time, a quarter or half an inch of the atrophied ends must be removed. When one bone only has been broken, the removal of this amount will cause a gap between the ends because of the unyielding sound bone; it will therefore be necessary to divide the latter at a suitable spot, preferably lower down so as to avoid union of the four fragments, and to remove enough of it to enable the fragments of the fractured bone to come into position (see Fig. 170). The treatment of the divided bone will be similar to that described in the preceding paragraph.

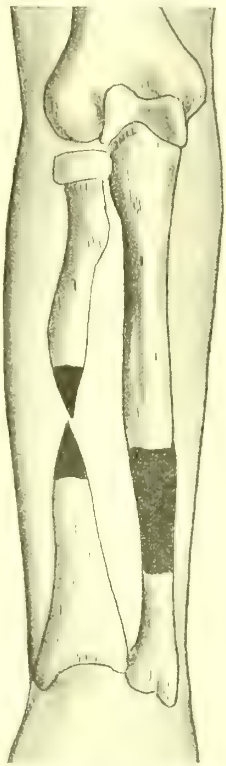


FIG. 170.—UNUNITED FRACTURE OF THE RADIUS. The dark parts show the portions of bone that must be removed.

In both ununited and badly united fractures it is advisable to fix the elbow-joint as well as the hand after operation, and a Croft's splint is the best method of doing this. The splint should extend as high as the axilla, otherwise the elbow-joint will not be properly fixed.

As soon as the wound has healed, the arm should be put up in a silicate casing which extends as high as the axilla, fixes the elbow at a right angle and keeps the forearm midway between pronation and supination; the wrist-joint should also be fixed, with the hand extended upon the forearm and the fingers left free. This apparatus should not be left off until union is complete. It must be confessed, however, that it is often difficult to get firm union after an operation for an ununited fracture of the forearm.

FRACTURES OF THE LOWER THIRD OF THE FOREARM.

The following injuries may be met with in this situation: Fracture of both bones a little distance above the wrist; separation of the epiphysis of the radius; fracture of the radius near its lower end—Colles's fracture; and fracture of the styloid process of the ulna.

COLLES'S FRACTURE.

This is by far the most important fracture in this region; it occurs at the lower end of the radius, usually from three-quarters of an inch to an inch and a half above the articular surface. It is accompanied by a characteristic displacement of the lower fragment and the hand, and is often complicated by rupture of the internal lateral ligament, or by fracture of the tip of the styloid process of the ulna.

The fracture is fairly common and is more frequent in old people than in young, and in women than in men. The usual cause is a fall upon the palm of the outstretched hand when the elbow is somewhat flexed; in young subjects, this accident is more likely to produce an injury about the elbow or shoulder-joints, but as life advances and the lower end of the radius becomes more brittle, it usually gives rise to a Colles's fracture.

In falls upon the palm the force is transmitted from the thenar eminence to the radius, and the bone breaks at its weakest part; at the same time the lower end of the radius is driven backwards and upwards, and is also somewhat rotated, so that the articular surface looks downwards, backwards, and somewhat outwards instead of directly downwards. The fracture is often impacted, the upper fragment being driven into the lower; it is not uncommon to find the latter considerably split up in these cases and the fracture extending into the joint. The line of fracture is usually transverse from side to side, but oblique from below upwards and backwards. There is frequently rupture of the internal lateral ligament of the wrist-joint, and in some cases the attachment of the triangular fibro-cartilage to the ulna is also torn through or the styloid process of the ulna is torn off.

TREATMENT.—The following are the chief points requiring attention in the treatment of these fractures : If the fracture be impacted its reduction requires considerable force, but it is most essential that reduction should be complete. Care must also be taken to see that the wrist-joint moves freely, and that the movements of pronation and supination are restored. There is always a great tendency to subsequent stiffness of the wrist and fingers, because of the close connection of the tendon sheaths with the lower end of the radius in the neighbourhood of the fracture. Teno-synovitis is a constant result, and is frequently followed by adhesion of the tendons to their sheaths. The tendons in front of the wrist are most liable to be thus affected, and the greatest care must be taken to avoid it. Adhesions will generally occur in the synovial membranes of the wrist.

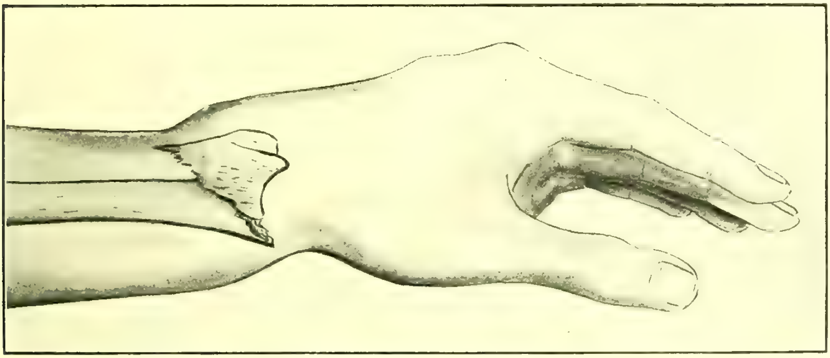


FIG. 171.—COLLES'S FRACTURE. The sketch shows how the characteristic displacement is produced.

Reduction.—This is the first point of importance. Reduction often calls for the exercise of considerable force, and it is therefore advisable to place the patient under an anæsthetic, when the fracture may be reduced by extension, and by forcing the lower fragment forwards. If no anæsthetic be given, reduction may be effected by grasping the limb and placing it palm downwards across the front of the knee with the styloid process of the ulna in contact with the patella, and then, by partly flexing and partly adducting the hand, the impaction may be undone. Care must be taken to see that the displacement is rectified completely ; the styloid processes of the radius on the two sides must be made to occupy the same relative level. After the fracture has been reduced, the fragments can be kept in place by grasping the lower end of the bone between the thumb and fingers ; the thumb is placed on the back of the wrist and presses forward the lower fragment, whilst the fingers press backwards the lower end of the upper fragment.

Splints.—The simplest and best splints that can be employed are straight anterior and posterior splints about the width of the forearm. In this case there is no fear of pressing the ends of the bone together unduly, and better fixation is obtained with splints the same breadth as the forearm. They should extend from the elbow to the metacarpo-phalangeal joints, that is to say, to the knuckles behind, and almost to the transverse crease of the palm in front. They should be cut to the shape of the forearm (see p. 172), and the anterior splint should be hollowed out or cut away opposite the thenar eminence, so that the thumb can hang down in a position of opposition. A pad should be placed over the posterior surface of the lower fragment, and a somewhat longer narrow pad should be placed along the front of the upper fragment, reaching down to its lower end. The splints are then fixed on firmly, with the forearm midway between pronation and supination. The fingers should be left uncon-

Fig. 172.—Splint for Colles's Fracture.

fined, and the patient encouraged to move them from the day following the accident. The surgeon should also move them freely every day, so as to avoid the risk of immediate adhesion of the tendons to their sheaths. The forearm should be supported in a sling.

After-treatment.—On and after the third day the posterior splint should be removed daily and gentle massage employed. At the end of the first week both splints should be taken off daily, and passive movement of the wrist, combined with pronation and supination, carried out, care being taken to avoid displacement of the fragments by grasping the lower end of the forearm with one hand and making pressure forwards over the lower fragment with the thumb, and backwards over the lower end of the upper fragment with the fingers. The splints may now be shortened, the anterior being cut away so that it ends opposite to the radio-carpal joint. The posterior splint should be continued and the hand bandaged to it ; this bandage may be removed daily to allow of movement of the wrist, while the anterior splint need not be disturbed as it does not interfere much with flexion.

During this time the forearm should be carried in a sling. At the expiration of eighteen days the splints should be left off entirely and the patient should be encouraged to practise active and passive movements of the fingers and wrist. The arm should be carried in a sling for another fortnight during the day, but at night the splint should be re-applied. Considerable œdema and pain sometimes remain for some time after these fractures, but early persistent massage will overcome it, and is indeed the most powerful preventive measure.

Various special splints have been introduced for the treatment of this fracture, but none will be found better than the one we have recommended. Carr's splint (see Fig. 173) is very popular; it consists of an anterior portion terminating in an obliquely placed bar which is grasped by the hand, and a narrow posterior one, which is applied along the dorsal surface of the radius from its upper end to just beyond the wrist joint. The outer or radial border of the anterior splint is thicker than the inner, and is hollowed out below for the reception of the lower fragment. The oblique bar at the lower end is grasped by the hand, which is thus brought into a position of adduction. The old 'pistol splint' has nothing whatever to recommend it.

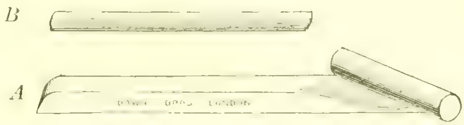


FIG. 173.—CARR'S SPLINT FOR COLLES'S FRACTURE. The splint illustrated is for the left limb. The oblique bar at the end of the anterior splint *A* is grasped in the hand. The radial border of the splint is considerably thicker than the ulnar. There is a depression in the radial side of the splint just behind the oblique bar into which lower fragment is pressed by the posterior splint *B*.

Mal-union.—Non-union is practically never met with in this fracture, but there may be mal-union, either because the fracture has never been reduced or because reduction has been imperfect; the hand may be much disabled thereby, but not by any means necessarily so. Should there be much functional disability the deformity should be corrected by operation, with a good prospect that the functions of the hand will be thereby restored. A long incision is made over the outer side of the lower end of the radius; the line of union is then chiselled through with the same obliquity as the fracture originally had, and the fragment detached and got into position. Mechanical methods of fixation are not necessarily required, as the surfaces are broad and union occurs readily. If, however, there is any tendency to recurrence of the deformity a light plate (see p. 307) should be applied where it will not interfere with the action of any of the tendons.

After the wound has been stitched up, splints are applied as described above, and should be kept on longer than in the case of a simple fracture. Equal care must be taken to carry out active and passive movements of the fingers and wrist. Passive motion of the fingers should be begun from the very first, and of the wrist after about ten days.

It occasionally happens that the displacement is very trivial, although a radiogram shows that there is a definite and typical fracture. If the movements of the joint are good, and especially if the pronation and supination are normal, it is usually wise to leave any slight displacement alone and attempt to restore mobility by massage and movements. This is particularly the case when the patient is not seen until several weeks have elapsed after the injury, which has been supposed to be a mere sprain of the wrist.

SEPARATION OF THE LOWER EPIPHYSIS OF THE RADIUS.

Separation of the lower epiphysis of the radius sometimes occurs in young subjects and is more often due to direct than to indirect violence. If any of the epiphyses give way in the latter form of violence, it is usually that of the lower end of the humerus. The line of separation is more transverse, the displacement is more directly backwards, and there is not the characteristic rotation of the lower fragment, nor do the fragments override as in cases of Colles's fracture.

Bad results not uncommonly follow this accident from arrest of development of the radius. This may be so considerable as to necessitate removal of a portion of the lower end of the ulna at a later period, in order to keep the articular surfaces of the two bones at their proper relative levels, and to prevent deviation of the hand to the radial side; a second operation may be necessary still later, in order to correct the deformity produced by continued growth of the ulna.

TREATMENT.—This is essentially the same as that of Colles's fracture (see p. 355).

FRACTURE OF THE STYLOID PROCESS OF THE ULNA.

This may occur in connection with Colles's fracture, but it may be met with as the result of a direct blow over the inner side of the wrist, as, for example, by a stick.

TREATMENT.—The limb should be put up with the hand in the abducted position so as to relax all tension upon the internal lateral ligament of the wrist-joint. Union is generally by fibrous tissue.

FRACTURES OF BOTH BONES.

Fracture of both bones at the lower end of the forearm is not common, and usually results from severe direct violence. The treatment is practically the same as for Colles's fracture (see p. 355).

FRACTURES OF THE BONES OF THE HAND.

FRACTURES OF THE CARPAL BONES.

Any of the bones of the hand may be fractured by direct or indirect violence. Direct violence usually takes the form of severe crushes, and the injury is then frequently a complex one and the fracture often compound. Indirect violence, generally a fall upon the outstretched hand, most commonly produces a fracture of the scaphoid or semi-lunar bones. This lesion was formerly considered to be very rare, but since the introduction of radiography it has proved to be comparatively common and should be suspected in all cases of severe 'sprained wrists.'

Except in the case of severe crushes, fractures of the carpal bones do not lead to much displacement, but in fracture of the scaphoid by indirect violence one of the fragments, usually the upper, is occasionally rotated through a considerable angle, so that the fractured surfaces may be entirely out of apposition.

TREATMENT.—In the case of the **severe crushes** which are compound, the ordinary treatment of a compound fracture and a wound of the joint is applicable. Any dirt, foreign body, or loose fragment of bone must be removed, and the question of amputation or excision will have to be considered, and will depend upon the amount of injury and on the risk of sepsis.

Simple fractures of the carpal bones may easily escape notice unless a radiogram has been taken. Examination under the screen is not sufficient. In uncomplicated cases the wrist-joint must be fixed on an anterior splint in the extended position and cold applications used to diminish the swelling. After two or three days massage end movements may be commenced. If a radiogram shows that there is rotation of one of the fragments, as is often the case with fracture of the scaphoid, it is better to expose the bone through a dorsal incision and to remove either the whole bone or the displaced fragment. The wound is closed without a drainage tube, and treated as for an uncomplicated fracture. Removal of the whole or part of a carpal bone affects the wrist-joint very slightly, but the muscles moving the joint should be vigorously treated by massage and exercises.

It occasionally happens in the case of the scaphoid that the fracture deprives one of the fragments of its blood-supply, and in consequence there is no union. The avascularised fragment, usually the upper one, remains as a foreign body in the joint and gives rise to a chronic synovitis with pain and weakness of the articulations, which can only be remedied by excising the loose fragment in the manner just described.

FRACTURES OF THE METACARPAL BONES.

Generally these are the result of direct violence, but sometimes they may be due to indirect violence, as in a fall upon the closed fist.

The first, second, or fifth metacarpal bones are most commonly broken ; sometimes there is very little deformity, sometimes there is some overlapping of the fragments. When the third or fourth metacarpal is fractured, the displacement is very slight, because the adjacent bones act as splints and keep the fragments in position. In some cases the fracture may be entirely overlooked, the patient only applying for advice when his attention is attracted to the mass of callus.

TREATMENT.—If there be any tendency to overriding, the fracture should be reduced by extension of the corresponding finger ; it then usually suffices to place a large ball of wool or worsted in the hand and forcibly flex the fingers over it, fixing them in this position with a stump bandage. A dorsal splint may also be put on to fix the wrist-joint, but it is seldom necessary unless there be some deformity over which it is desired to apply a certain amount of pressure. There is a tendency for the extensor tendon to adhere to the bone in the region of the fracture, and, with a view of avoiding this, the fingers should be released at any rate once a day so as to allow the patient to extend the finger. At the end of a fortnight the apparatus may be discontinued except in the case of very oblique fracture of one of the outer metacarpals, when it should be kept on for a week longer. After the splint has been discontinued, the patient should carry the arm in a sling for another week and should be encouraged to move the fingers both actively and passively. Massage is also beneficial in promoting the free mobility of the fingers, and may be practised from the first with advantage.

FIG. 174.—METAL SPLINT FOR FRACTURES OF THE PHALANGES. The trough receives the finger, while the flattened rounded portion goes into the palm of the hand.

FRACTURES OF THE PHALANGES.

Fracture of the phalanges by direct violence is not at all infrequent. The first phalanx is most commonly fractured owing to its greater length and mobility. The displacement varies according to the cause of the fracture, but in most cases it is slight.

TREATMENT.—After the fracture has been reduced, a moulded splint of block-tin or gutta-percha should be applied. The block-tin splint is the more useful and should be put on the anterior surface and cut, so that it covers the greater part of the palm ; this palmar portion fixes the metacarpo-phalangeal joint (see Fig. 174). The splint should be kept on for three or four weeks. After the first week the fracture should be taken down daily, and, whilst the fragments are fixed, the

joints should be well moved and the patient encouraged to flex them, in order to avoid adhesion of the tendons as a result of teno-synovitis set up in the immediate vicinity of the fracture, and also to avoid adhesions of the tendons to the broken bone. Union usually takes place rapidly. If the fracture be compound, the treatment must be that of compound fracture in general.

CHAPTER XVIII.

FRACTURES OF THE PELVIS.

THESE injuries are generally of a serious character on account of the lesions of important organs that so often accompany them. They are best grouped into fractures of the pelvic girdle as a whole and fractures of the individual components of the pelvis.

FRACTURES OF THE PELVIS AS A WHOLE.

Fracture of the pelvic girdle is commonly caused by a heavy body compressing and crushing the pelvis between it and the ground, or some other unyielding structure. The fracture is often bilateral; it may be situated on either side of the symphysis, or just outside the symphysis on one side and close to the sacro-iliac synchondrosis on the other. The fracture outside the symphysis generally passes through the horizontal ramus of the pubes and the ascending ramus of the ischium, which are the weakest spots in the pelvic girdle (see Fig. 175).

One portion of the broken pelvis is often driven inwards and damages the parts immediately beneath. The structure most commonly involved is the urethra, the condition of which must be investigated in every fracture of the pelvis; the laceration is generally in the membranous portion, and the urethra may be torn across completely or partially. This injury is dangerous, as it may be followed by extravasation of urine, and it is, therefore, of the highest importance to ascertain its presence and to adopt appropriate treatment without delay; it is generally indicated by bleeding from the external meatus. The bladder is also frequently injured, especially if it be distended at the time of the accident. The rectum or the vagina, and the femoral or the iliac vessels, may also be lacerated.

TREATMENT.—When the pelvic girdle is fractured, the first points requiring attention are the shock, which is always present and is generally very severe, and the condition of the structures which are

liable to damage. The shock may be treated on the lines laid down in Vol. I. p. 118, but stimulants should be withheld until it has been ascertained whether the large vessels are damaged. Directly he is seen, the patient should be warned not to attempt to pass water; extravasation of urine, which is an avoidable occurrence, can thus be prevented. A patient whose urethra or bladder is damaged experiences a strong desire to pass water, and will do so unless he be warned to the contrary. The condition of the urethra and the bladder should be ascertained as soon as possible, and, if damaged, these structures should

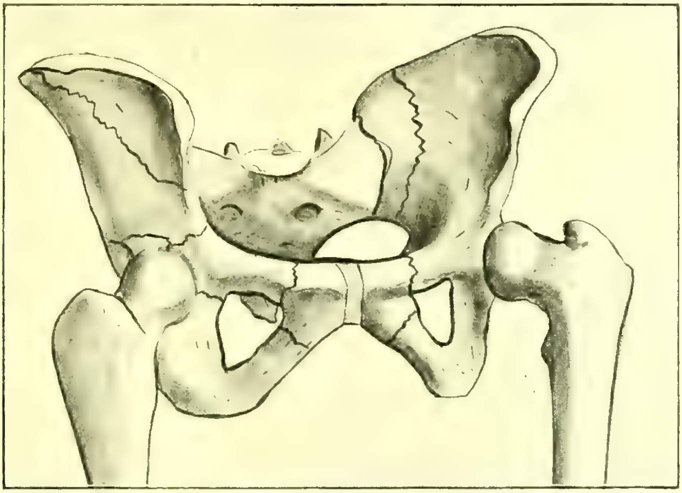


FIG. 175.—FRACTURES OF THE PELVIS. Diagram to show where the fractures may occur.

be treated appropriately. This is described among injuries of the bladder and urethra (see Vol. V.). As soon as possible a stereoscopic radiogram should be obtained.

The patient should be placed upon a firm mattress over fracture boards, with the knees flexed over pillows. If possible the mattress should be so arranged that it is not necessary to disturb the patient for the purpose of defæcation; either a perforated mattress or one provided with a removable segment is very useful. A broad bandage of unbleached calico should be applied firmly around the pelvis in order to prevent the falling apart of the sides of the pelvic girdle. If possible any displacement present should be remedied whilst the bandage is being put on. There may be considerable deformity, the rectification of which is a matter of importance in a female; permanent pelvic narrowing which would interfere with child-birth might otherwise result. The most severe deformity results from depression of the symphysis pubis; this is more easily reduced in the female by means

of the finger in the vagina. To enable the proper manipulations for reduction of the deformity to be carried out effectually an anæsthetic is necessary.

During the first fortnight it is necessary to avoid distension of the abdomen, as this is calculated to pull upon the fragments through the agency of the abdominal muscles, and thus to give rise to considerable pain; suitable laxatives and enemata must therefore be administered. Three or four weeks must elapse before sufficient union has occurred to enable the patient to be moved without pain, and it will be about eight weeks altogether before he can be allowed to sit up; after another two or three weeks he may be allowed to get about, at first with crutches, and later on with two sticks.

FRACTURES OF THE INDIVIDUAL BONES OF THE PELVIS.

When any of the individual bones forming the pelvis are fractured separately the treatment varies slightly.

FRACTURES OF THE ILIUM.

The alæ of the ilium are not uncommonly fractured by severe localised direct violence; the fracture is generally limited to the false pelvis.

TREATMENT.—The patient should be placed in bed with the knees flexed and fastened over a pillow; it is not advisable here to apply a bandage as in the cases just described, because its pressure would be likely to drive the fragments inwards. A stout sandbag on either side of the pelvis with a sheet stretched over the abdomen will suffice to keep the parts at rest. The patient may get up in about three weeks, using crutches at first, and afterwards getting about with the aid of a stick.

FRACTURES OF THE ISCHIUM.

The tuberosity of the ischium may be fractured, and the separated portion of bone is sometimes drawn downwards by the muscles attached to it. Often, however, there is no separation, owing to the fact that the ligamentous structures in the neighbourhood are untorn.

TREATMENT.—When there is little separation, an attempt may be made to obtain union by relaxing the muscles attached to the ischium; for this purpose the patient should lie on the opposite side with the thigh fully extended upon the pelvis and the knee flexed. Since union will be by fibrous tissue, it is better to cut down and expose the fracture in all cases in which there is much separation, and then to fix it in position with pegs or screws.

FRACTURES OF THE ACETABULUM.

The rim of the acetabulum may be broken off, or the fracture may run through the centre of the cavity; it may sometimes be so extensive that the head of the femur passes in between the broken fragments and projects into the pelvis. The accident may result from a fall on the knee, and this form of violence generally leads to detachment of a portion of the upper and back part of the rim of the acetabulum; the result is that the head of the bone has a constant tendency to escape from the acetabulum and to slide upwards and backwards on to the dorsum of the ilium. Sometimes, however, it is due to a severe fall or blow upon the great trochanter, which drives the head of the bone forcibly against the bottom of the acetabulum, and then fracture takes place in that situation.

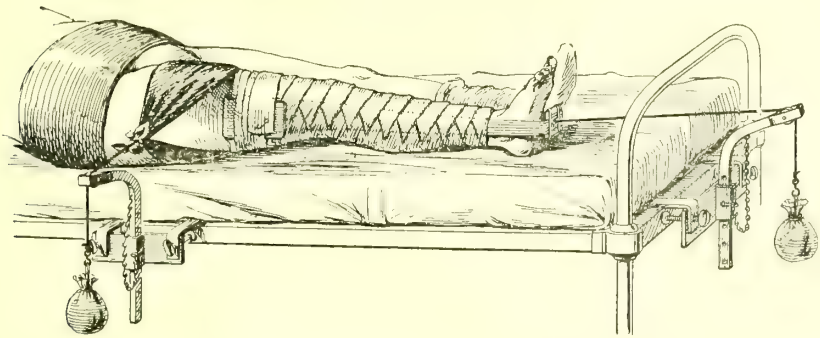


FIG. 176.—EXTENSION APPLIED FOR FRACTURE OF THE ACETABULUM. In addition to the ordinary weight extension from the foot, there is a second extension at right angles to the long axis of the limb through the agency of a sling passed transversely around the upper part of the thigh. Counter-extension is made by a broad towel around the pelvis fastened to the side of the bed opposite to that on which the pulley is. The foot of the bed is raised on blocks.

TREATMENT.—*When the rim of the acetabulum is chipped off*, extension with the limb in the fully abducted position should be employed after the head of the bone has been manipulated into position; in adults a weight of six or eight pounds will generally suffice. The extension should be kept up for at least six weeks; passive motion should be begun after three weeks and repeated daily. Extension by means of a long splint is seldom sufficient to prevent the head of the bone slipping out of position again.

Fractures of the acetabular cavity are rare, and, being usually the result of very severe violence, are often complicated by fracture of the neck or the head of the femur, injury to the pelvis elsewhere, or damage to the pelvic organs. The exact condition of affairs is difficult to make out, and a stereoscopic radiogram should always be obtained.

With the patient under an anæsthetic, an attempt should be made

to disengage the head of the bone from the acetabulum; the upper end of the femur is pulled outwards by a band passed horizontally around the upper part of the thigh, and extension is also made in the long axis of the limb. Then, by means of the finger in the rectum, it is possible that the fragments may be manipulated into position. If this should be the case, the limb must be put up with extension applied in two directions, partly in the long axis of the limb and partly at right angles to the upper part of the thigh, so as to keep the head of the bone as far away from the bottom of the acetabulum as possible (see Fig. 176). Passive movement should be begun after the end of the first week, with the view of minimising the resulting stiffness of the hip-joint. It is, however, very rare that an entirely useful joint is obtained after an injury of this kind.

Should manipulation fail to restore the parts to position, it will be better to expose the seat of fracture and to restore the normal condition of affairs as far as possible than to leave the case alone, in which case very severe deformity would result.

FRACTURES OF THE SACRUM.

On account of its great strength and its comparatively sheltered position, the sacrum generally escapes injury, but fracture may occur from direct violence, such as kicks or blows, or a run-over accident when the patient is lying upon the face. As a rule the fracture takes place just above the sacro-coccygeal joint.

This fracture is generally compound, communicating either with the skin or the rectum. In the latter case the injury is grave, as septic infection is almost certain, and may lead to pelvic cellulitis of a severe type. Damage to the sacral nerves may also occur, and may lead to paralysis of the sphincter ani and incontinence of fæces.

The lower fragment, with the coccyx attached to it, is generally displaced forwards, and, even when there is no displacement immediately after the accident, the lower end tends to be tilted forward subsequently by the muscles attached to it. The fracture may unite in this bad position, and will then exert pressure upon the lower end of the rectum, interfering with the passage of its contents, and often causing great pain and discomfort to the patient on sitting or walking—a condition generally spoken of as *coccydynia*.

TREATMENT.—The chief point in the treatment is to reduce the fragments, so that there shall be no tilting forwards of the lower end, and also to arrange that the bowels shall be confined for some days. The rectum should first be emptied by an enema. The finger is then introduced into the rectum, the lower fragment of the sacrum is grasped between it and the thumb externally, and manipulated into position. Twenty minims of laudanum in half an ounce of starch are then introduced into the rectum, so as to prevent any further action of the bowels

for four or five days. The patient should be instructed not to assume the dorsal decubitus. Union usually occurs satisfactorily if the fracture be simple, and the patient may be allowed to get up in three weeks; he should not be allowed to sit down until six weeks have elapsed.

When the fracture is complicated by a wound of the skin and there is difficulty in preventing the tilting of the lower fragment, the ordinary treatment for compound fracture should be carried out, and it will be well to fix the fragments together (see p. 305), or else to remove the lower piece. These cases, however, often suppurate owing to the proximity of the wound to the anus. The treatment of cases, in which the rectum is wounded, is dealt with in connection with the injuries of that organ (see Vol. IV.).

FRACTURES OF THE COCCYX.

Fracture of the coccyx may be caused by direct violence, such as falls in the sitting position, kicks or blows, etc. It sometimes occurs during parturition, and closely resembles fracture of the sacrum. The bone is usually broken in the vicinity of the sacro-coccygeal joint and the fragment is always displaced forwards; it may press upon the rectum and give rise to pain on sitting or standing—the condition known as *coccydynia*. This fracture is often overlooked, and the displacement is therefore not rectified, with the result that the fractured ends unite in bad position and much pain results.

TREATMENT.—The treatment is very similar to that of fracture of the sacrum. The rectum should be emptied, and then an effort is made to replace the broken fragment by grasping it between the fore-finger in the rectum and the thumb over the skin outside, and manipulating it into place; when this has been done, an enema of starch and laudanum is given. There is, however, a constant tendency for the fragment to become displaced forwards, and if the fragment will not remain in position, it is best to cut down and either fix the fragment by a wire or to excise it altogether.

Operative measures, however, should not be employed until the effusion about the fracture has become absorbed. Septic infection is prone to occur in the wound as the result of its proximity to the anus, and might be grave if the soft parts were much damaged. Therefore, persevering attempts should be made for the first fortnight to replace the bone as often as it becomes displaced. After that, operation may be resorted to if these efforts fail.

Operation.—A median vertical incision is made down to the bone, the periosteum and fibrous structures are peeled back with a rugine, the fragment is seized in forceps and removed by a few touches of the point of the knife, the woundis sutured, and it is well to fasten the dressing on with collodion. Should septic infection occur, the stitches must be removed, a drainage tube inserted, and wet boric dressings applied.

CHAPTER XIX.

FRACTURES OF THE FEMUR.

Fractures of this bone may be divided into those affecting the upper end, the lower end, and the shaft.

FRACTURES OF THE UPPER END OF THE FEMUR.

These fractures are divided into those of the neck and those of the great trochanter. Fractures of the neck of the femur are again usually subdivided into the intra-capsular and the extra-capsular forms. In the intra-capsular fractures the line of fracture is assumed to lie within the capsule of the joint, whilst in the extra-capsular forms it lies outside it. As a rule, however, the distinction between the two forms is not perfectly accurate, because the line of fracture is generally partly intra- and partly extra-capsular in its course; the fracture is really called intra- or extra-capsular according as the greater part of the line of fracture is within or without the capsule.

INTRA-CAPSULAR FRACTURE.

True intra-capsular fracture is comparatively rare, and is most frequent in old people in whom senile bone changes are marked. In old subjects a process occurs, termed osteoporosis, in which the bone becomes unduly porous and brittle, and the direction of the neck of the bone also becomes more horizontal; the line of fracture is usually close to the head of the bone.

The fracture is generally caused by a comparatively slight injury, such as a fall upon the knee or the trochanter. When it results from indirect violence, such as a fall upon the knee, there is no impaction, but when it follows blows upon the trochanter, some impaction is not uncommon, the neck of the bone being driven into the head. The impaction, however, is not usually permanent and is not firm enough to insure bony union.

The shaft and the outer part of the neck are generally drawn upwards, partly as a result of the force and partly by muscular contraction, and consequently there is always shortening of the limb. In true intra-capsular fracture this shortening is slight, rarely exceeding three-quarters

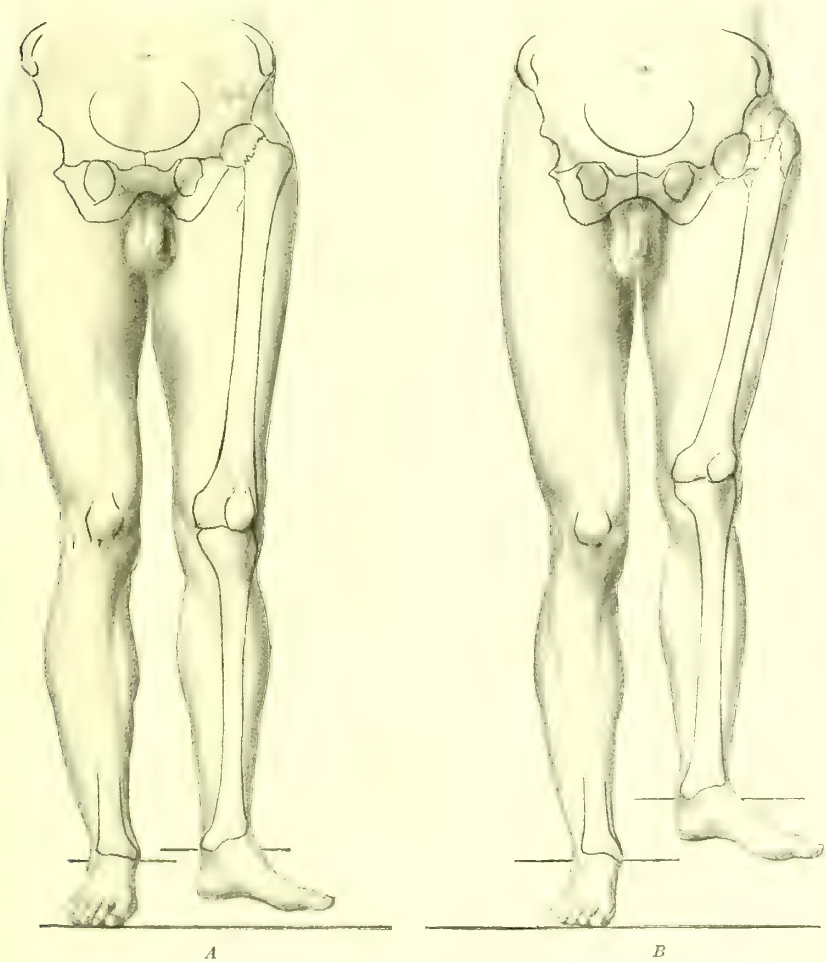


FIG. 177.—FRACTURES OF THE NECK OF THE FEMUR. To show the position of the limb and the shortening. *A*, Intra-capsular fracture. *B*, Extra-capsular fracture.

of an inch at first. Later on, unless means be taken to prevent it, the shortening may become more pronounced owing to the contraction of the muscles and the gradual stretching of the capsule; the latter is the principal agent in preventing the bone from being drawn upwards to any great extent immediately after the injury. The limb is rotated outwards, so that the foot is everted and lies with its outer border

almost horizontal. In unimpacted fractures this is mainly due to the weight of the limb, but it is also probably due in part to the fact that there is more extensive crushing of the bone on the posterior aspect of the neck than on the anterior, because the same eversion occurs in impacted fractures, and in them, of course, the weight of the limb cannot produce much effect so long as the impaction holds.

TREATMENT.—In the case of old people two important points should be borne in mind. In the first place, the fracture often fails to unite by bone, although this is not always the case if prolonged treat-

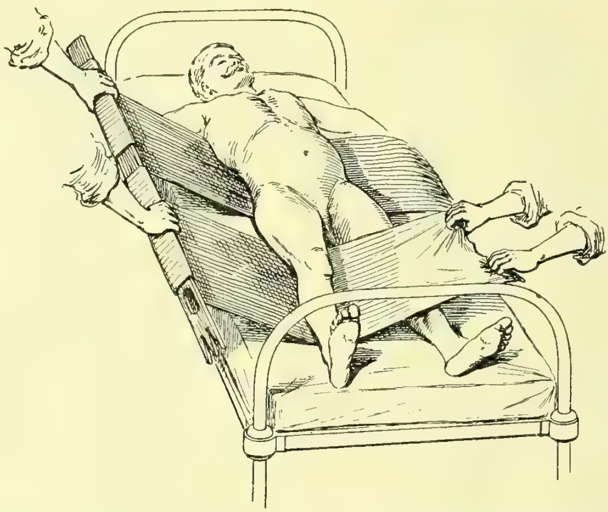


FIG. 178.—LISTON'S LONG SPLINT. *Method of application.* The splint is first rolled up for a few turns in one end of each of the broad bandages or sheets. The latter are then arranged as in the figure, the upper one beneath the trunk and pelvis, which keeps it steady, and the lower one beneath the affected limb, where it is held firm by an assistant. The splint is then further rolled up in the bandages until it lies against the side of the body, when pads are inserted and it is secured as shown in the following figure. For the cases referred to in the text a stirrup should be applied to the affected limb before the procedures depicted above are carried out.

ment be carried out. In the second place, a long period of recumbency after any injury may prove serious, and indeed fatal, from the occurrence of hypostatic pneumonia.

If the patient be comparatively young and strong, it may be worth while to attempt to obtain bony or firm fibrous union between the fragments; if, on the other hand, the patient be old, it is not worth while running the risk of pneumonia by persevering in the use of the recumbent position in attempts to obtain bony union. The question of union will also be affected by the presence or absence of impaction. When the fracture is impacted, the surgeon will be more inclined to persevere in attempts to obtain bony union than when it is not.

Of Unimpacted Fractures in Young Adults.—The best treatment

for an unimpacted fracture in a comparatively young and vigorous subject is as follows : The patient must be placed flat upon the back in bed with fracture boards beneath the mattress, and the latter should be so arranged that there is the least possible disturbance involved in the action of the bowels, etc. ; the divided mattress (see p. 363) may be usefully employed for this purpose. When, after prolonged confinement to bed, the skin shows a tendency to become the seat of bed-sore, a suitable ring-pad or water-pillow should be placed beneath the pelvis, but this is best avoided in the earlier stages of the treatment, as the body is kept steadier without it. All the ordinary precautions against bed-sore must be rigorously observed (see Vol. I. p. 70).

Extension.—Traction should be made upon the fractured limb until measurements show that it is the same length as the sound one; this

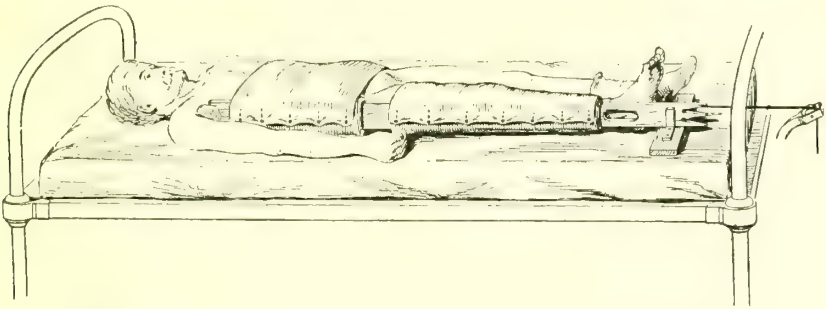


FIG. 179.—LISTON'S LONG SPLINT. *The splint applied.* After the splint has been put in position the free end of the upper sheet is brought around the thorax and pinned to the portion rolled up around the splint as shown above. The lower sheet is brought around the extremity and similarly fastened. The slot for preventing rotation is shown at the lower end of the splint, and the extension apparatus is also indicated. The lower extremity is slightly abducted.

traction should be kept up by means of a weight and pulley applied in the usual manner, the strapping being carried half-way up the thigh so as to avoid unnecessary strain upon the ligaments of the knee. The foot of the bed is raised upon blocks so as to produce counter-extension, and a weight of from four to eight pounds is employed. The exact weight is determined by measurements of the limb and by the patient's sensations. Only such a weight should be employed as is necessary to make the two limbs of equal length. The measurements should be taken from the anterior superior spine of the ilium to either the tubercle of the tibia or the internal malleolus, and it is well to mark these spots upon the skin with an aniline pencil or with a solution of nitrate of silver at the commencement of the treatment, so as to be sure that the measurements are always taken from the same points. A small pillow is placed beneath the leg just above the heel to prevent the formation of a pressure sore upon the heel, which might occur were the heel to rest upon the mattress.

Liston's Long Splint.—The next point is to overcome the eversion of

the foot, and to see that the patient is kept strictly horizontal. This can be done by means of a long Liston's splint reaching from the axilla to beyond the heel, but without a perineal band. The splint is applied in the following manner: A sheet is folded so that its width is equal to the distance from the perineum to the heel, and another so that its width is equal to the distance from the axilla to the iliac crest. The long splint is laid upon one end of each of these folded sheets, which are arranged so

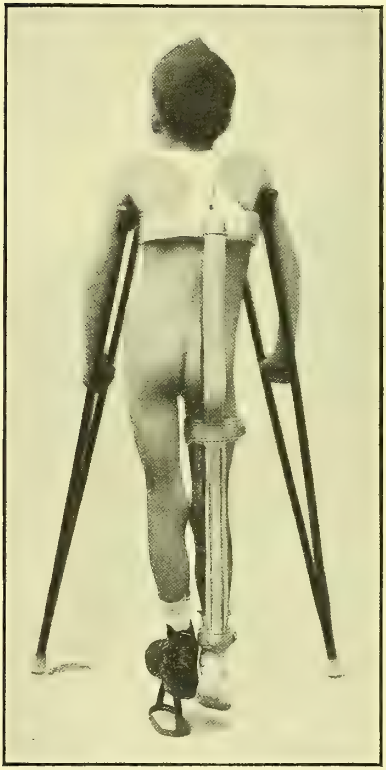


Fig. 180.—Thomas's Hip Splint applied. *Back view.*

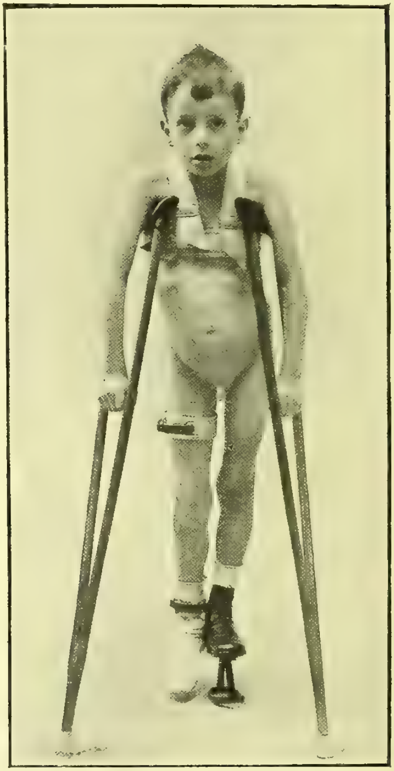


Fig. 181.—Thomas's Hip Splint applied. *Front view.*

(Photos supplied by Allen & Hanburys, Ltd.)

that they will be in proper position when the splint is applied, and the latter is rolled up in them for three or four turns so as to fix them firmly (see Fig. 178); the free end of the upper sheet is then passed beneath the trunk and that of the lower one around the lower extremity. The limb is brought into the correct position by traction and slight abduction, and the splint is then applied, pads being inserted between it and the limb where necessary. The upper sheet is now brought round the chest and fastened to the splint by means of long blanket pins, while the lower

one is wound around the lower extremity and the splint so as to fasten the two firmly together, and is similarly pinned to the splint. The best way to prevent recurrence of the eversion is to make the lower end of the splint slide in a slot formed by two rectangular iron brackets screwed side by side on to a flat wooden cross-piece that lies on the mattress: in this it is free to slide horizontally, but is unable to rotate (see Fig. 179).

When an attempt is to be made to obtain true bony union, this apparatus should be kept on for ten or twelve weeks; the usual period of six weeks is too short for intra-capsular cases. During this prolonged treatment it is necessary to see that bed-sores do not occur, that the patient is kept absolutely quiet, and that there is no ulceration of the skin from the extension apparatus. At the end of ten weeks the hip-joint should be fixed in a Thomas's hip splint (see Figs. 180–2), and the patient may then be allowed to get about upon crutches which should be used for at least two months before he puts the foot to the ground. After prolonged treatment of this kind the union will gradually become firm enough to allow the patient to support nearly his full weight upon the injured limb.

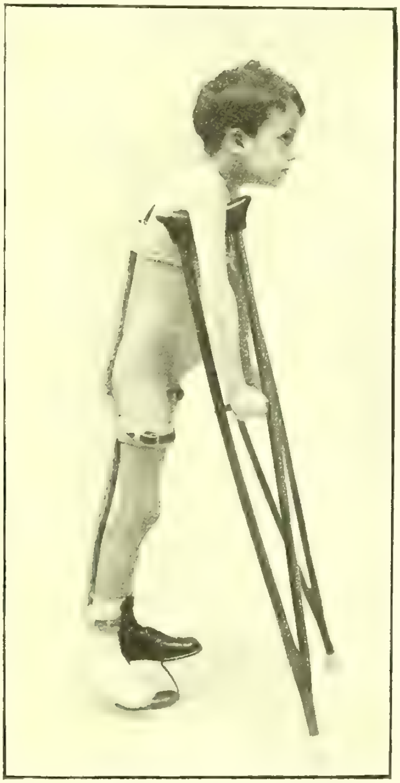


FIG. 182.—THOMAS'S HIP SPLINT APPLIED.
Side view.
(Photo supplied by Allen & Hanbury's, Ltd.)

Plaster Spica.—In men the plaster of Paris spica bandage is useful: it may be used either for recent cases or for those in which some union has occurred. It is put on as follows: The patient stands on the sound limb upon a block high enough to raise the affected limb well off the floor. After the perineum and the groins have been dusted with boric powder, a spica of boric lint or ordinary flannel is applied to the affected limb from the upper third of the leg to above the crest of the ilium. Over this the plaster of Paris bandages are applied[1] and they may be strengthened by smearing a quantity of the plaster over them with the hand.

[1] For the method of preparing and applying these bandages see p. 273.

The weak point in the bandage opposite the fold of the groin should be strengthened by incorporating in its folds strips of block-tin or thin malleable iron across the fold of the groin at right angles to Poupart's ligament and in a corresponding situation behind. As a substitute for these, strands of tow teased out and steeped in plaster may be used in a similar manner, but they will not stand so great a strain as the metal. The apparatus should be firm enough not to crack when the patient's full weight is borne upon it, and as light as is consistent with this. It must be allowed to dry thoroughly before any weight is borne upon it. With this object the patient may lie in the horizontal position before a fire for some hours. For recent cases it is much more satisfactory to apply the apparatus when the patient is erect, as the weight of the limb then acts as an extending force; if, however, it has to be put on while the patient lies in bed, extension by weight and pulley or by an assistant must be maintained. When the plaster has set, a boot with a high heel or a patten (see Fig. 180) is worn upon the sound limb and the patient is allowed to get about on crutches, the toes of the affected limb being slung by a long strip of bandage passing round the neck and beneath the instep.

The plaster spica is very useful because it allows the patient to bend the lumbar spine and so he can be propped up in bed; the risk of lung complications is thus minimised. It may require renewal and should be worn for three or four months; a Thomas's splint may then be substituted for another two or three months. Fairly firm nnion may be obtained by this method.

The Ambulatory Method.—The ambulatory methods of treatment of these injuries and, indeed, of all fractures of the lower extremity has been adopted by Hessing with considerable success and we have used Hoefftcke's modification of his splint with excellent results. A plaster cast of the leg is taken and on this the splint is moulded. It consists of a thigh-piece made of perforated leather strengthened with steel bands prolonged below into two lateral steel bars, terminating in a flat foot-piece an inch below the sole of the foot. When the patient is standing, the weight of the body is borne on the tuber ischii and transmitted to the ground through the lateral steel bars. The foot, encased in an accurately fitting anklet, is so arranged that constant extension can be kept up, and the leg is steadied in the splint by a padded leather sheath moulded accurately to it below the knee and laced up down the front. There are hinges opposite the ankle-joint, and in those used for fractures high up in the femur there is a hinge opposite the hip-joint connected with a pelvic band, which not only steadies the apparatus, but prevents external rotation.

The splint may be safely applied as soon as the initial shock of the injury has been overcome, and should be worn continuously for the first three weeks. It may then be removed twice a day for massage, and about a fortnight later it may be taken off at night and the patient allowed to move the leg freely in bed. Patients wearing this apparatus need not

be confined to bed for more than a few days, and may then be allowed to commence walking with the assistance of two sticks. There is often some swelling of the limb below the fracture, but this usually gives no trouble. The disadvantage of the splint in fractures of the neck of the femur is that, if movement be allowed opposite the hip-joint, movement occurs at the line of the fracture and not in the joint itself, hence non-

FIG. 183.—HOEFFTCKE'S EXTENSION SPLINT FOR FRACTURES OF THE FEMUR. The right-hand figure shows the back view of the apparatus for a fracture of the neck of the femur. The left-hand one is a front view of that used for a fracture of the shaft of the bone. Both splints are identical in construction except that a pelvic band is added for fractures of the neck of the bone. (*Hoeffcke.*)

union may occur. If bony union of the neck of the femur be desired the hip must be immobilised. The splint, however, is of great value in old people whom it is impossible to keep immobilised long enough to obtain firm union. Hence in young and vigorous patients in whom the chance of union is good, the older methods are to be preferred at first, Hessing's splint being only applied towards the end of the case. When, however, the chances of union are not good, or the patient is old and feeble, Hessing's

splint should be applied as soon as possible and the patient allowed to get up.

Mechanical Fixation of the Fragments.—The question of operative interference in these cases has been a good deal discussed. The patient is usually too old and feeble to undergo what must necessarily be a severe operation, and, besides this, the bone is generally so much atrophied that the chance of getting a good result is not good. When, however, the fracture occurs in a comparatively young and vigorous patient (45–55) operation may be justifiable. In more than one case of this kind in which the fracture was apparently intra-capsular, we have operated with success.

Under an anæsthetic extension by weight and pulley is made in the first instance upon the limb until the two limbs are of the same length. The femur is then rotated firmly inwards and the parts manipulated until the fragments seem to be in position. The neck of the femur is then exposed by means of an incision running obliquely downwards and inwards from the anterior superior spine of the ilium, over the interval between the sartorius and the tensor vaginæ femoris muscles, and by means of this the surgeon can assure himself that the fragments are in good position while they are being fastened together. A vertical incision is then made over the outer surface of the great trochanter right down to the bone, and a drill driven through the trochanter and along the neck of the bone until it penetrates well into the head of the femur. The distance the drill penetrates is determined by measurements on the sound side, and also by the finger in the anterior incision. The drill is then withdrawn and a square ivory peg fitting the hole exactly is driven in and cut short. It is well to drive in a second peg higher up. A long Liston's splint is then put on and weight extension applied.

The splint may be left off in six weeks, and for the following month the patient should be encouraged to move the hip as she lies in bed without being allowed to bear weight upon it. If the union be not firm, a Hessing's splint should be worn until that is the case.

Of Impacted Fractures in Young Adults.—Here the long splint alone is often sufficient, but, as the impaction is frequently slight, amounting sometimes to a mere entanglement of irregular fragments. it is well to employ extension also. Two or three pounds usually suffice.

Of Fractures in Elderly and Feeble Subjects.—In these patients it is not advisable to attempt to obtain bony, or even firm, fibrous union, and when the patient can afford it, the best plan is to apply Hessing's splint as soon as possible and to get him up. At the first the patient must be kept on a couch; next, he should be encouraged to stand with help and to sit more upright, while finally he may he able to get about with crutches or a stick.

EXTRA-CAPSULAR FRACTURE.

By this term is understood an injury in which the line of fracture is outside the capsule, at any rate in part of its course. As a rule, it is intra-capsular in front and extra-capsular behind, owing to the fact that in front the capsule is attached to the lowest limit of the neck.

This injury is caused by more severe violence than that which produces the intra-capsular fracture and is generally due to a heavy fall on the great trochanter ; impaction frequently occurs, the neck of the femur being driven outwards into the trochanter, which it may split up considerably. The injury may also occur from indirect violence, such as falls from a height upon the feet or knees, but in these accidents the shaft of the femur is more likely to be broken. The fracture occurs in younger people than does the intra-capsular variety, and generally unites by bone. As it occurs in younger subjects there is less liability to lung complications than in the intra-capsular fractures.

There is generally shortening, even when the fracture is impacted ; as much as two to three inches may be met with. The limb is strongly everted whether impaction be present or not. In impacted cases there is broadening of the trochanter—a point of importance in the diagnosis.

TREATMENT.—In two respects the treatment of this fracture differs from that of the intra-capsular variety. In the first place, the surgeon's object is to obtain bony union, and, therefore, a prolonged treatment is advisable and is usually well borne, since the younger and more vigorous patients do not run the same risk of bed-sore or pneumonia as do the victims of intra-capsular fracture. In the second place, powerful extension is required to keep the fractured surfaces in position, because there is nothing to oppose the upward pull of the muscles. The treatment will vary according as the fracture is impacted or is not.

Of Unimpacted Fractures.—The limb is shaved and extension strapping applied from the middle of the thigh to about the middle of the leg (see p. 276) ; the bandage securing it should not extend as low as the malleoli, because heavy weights have to be employed which may cause the strapping to slip and produce a sore about the ankle. As an alternative the extension apparatus may be attached to a well fitting spat (see p. 277). After the strapping has been applied, the patient should be anæsthetised and the limb dragged down into position by traction upon the foot and ankle, while an assistant makes counter-extension ; a suitable weight which will vary with the muscularity of the patient is then attached to the cord passing over the pulley. In an adult it is best to begin with six or seven pounds and increase it, if necessary.

The outward rotation of the limb will also have to be corrected, and this is much more difficult to do than in the intra-capsular fracture,

because any efficient arrangement is likely to cause so much friction that the extension is interfered with. A good, though somewhat complicated, apparatus is shown in Fig. 184. The foot and lower part of the leg are put up on a posterior splint with a foot-piece at right angles, so arranged that it runs in a groove in an iron frame standing upon the bed; rotation of the limb is thus prevented without undue friction. This apparatus is not easily obtainable, however, and the following simple method may be tried. A piece of wood three inches wide and nine inches long is placed behind the knee so that it projects beyond it on each side, and is then fastened firmly to the limb by a plaster of Paris bandage after the rotation has been corrected (see Fig. 185). This is a better apparatus than the long Liston's splint with the transverse bar, which is often used for the same purpose, as it does not interfere so much with the extension.

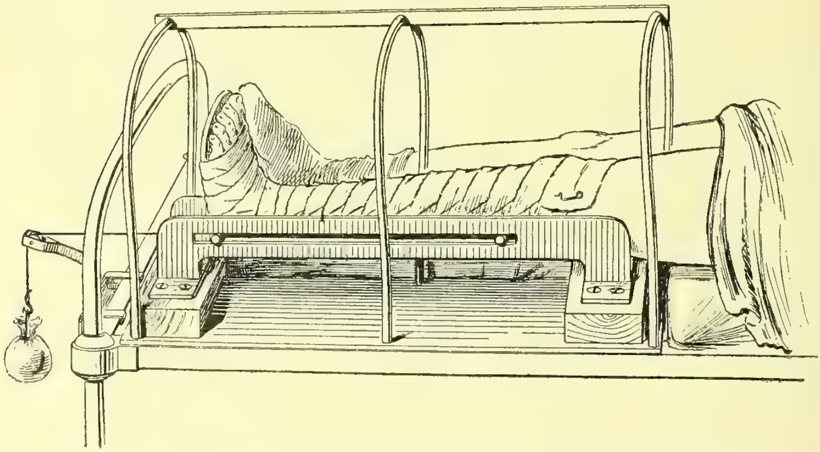


Fig. 184.—Extension Apparatus for Fracture of the Neck of the Femur. The leg is fixed to a back splint which slides in the iron frame shown above. This serves to prevent rotation while securing extension without friction against the bed.

Another point of importance is to fix the body so that the patient cannot move the hip-joint, as otherwise movement will occur at the seat of fracture, and union may be interfered with. This is best done by applying a long Liston's splint to the sound side; in addition, a sheet may be placed across the trunk and kept in position by sandbags on either side. The splint is put on the sound side so that it shall not interfere with extension of the fractured limb, or exert undue pressure over the damaged trochanter. When the patient is not restless the Liston's splint is not necessary, and he may be kept steady by passing a broad sheet across the thorax, and keeping it in position by heavy sandbags rolled up in it on each side.

After-treatment.—The patient should be kept in the horizontal position for at least six weeks. At the end of that time a Thomas's hip-splint may be fastened on with plaster of Paris bandages and the patient may

be allowed to get up on crutches. The Thomas's splint should be worn for six weeks, when, in all probability, the fracture will be firm. After these fractures have united there is often some limitation of movement in the hip-joint, due either to adhesions in the capsule or to callus thrown out around the fracture. The adhesions in the joint may be overcome by massage and active and passive movements, but if the movement be interfered with by bony outgrowths, it may be necessary to cut down over the trochanter and chisel away any portions of bone that interfere with the mobility of the joint. A stereoscopic radiogram will help greatly in determining this point.

Pegging.—In some cases of extra-capsular fracture it may be advisable to peg the fragments together in the manner described in dealing with intra-capsular fracture. We have never had occasion to do this, but when there is difficulty in keeping the patient quiet, when the fragments cannot be kept in position, or when the skin is so tender that efficient weight-extension cannot be tolerated, operation may undoubtedly be called for. A couple of pegs driven in through the trochanter would probably fix the fragments and ensure good union. The steps of the operation would be similar to those already described for intra-capsular fracture (see p. 376).

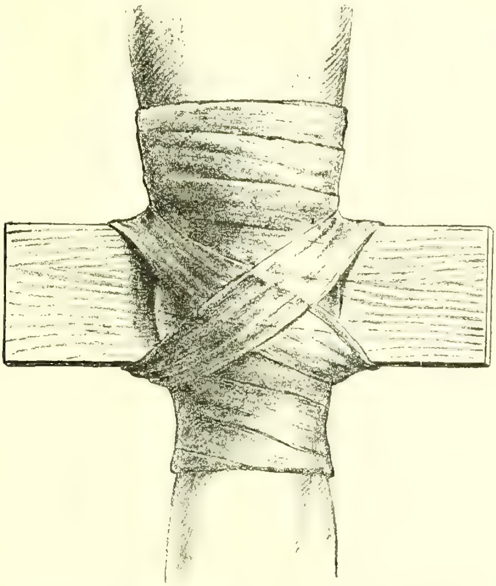


FIG. 185.—METHOD OF PREVENTING ROTATION DURING WEIGHT EXTENSION FOR FRACTURE OF THE FEMUR. A plaster of Paris bandage is applied to the knee and made to include a piece of board placed behind the limb as shown in the figure.

Of Impacted Fractures.— When the fracture is impacted it is not advisable to break up the impaction unless there be great deformity, such as extreme eversion. It is only necessary to keep the limb at rest until bony union occurs, which generally takes place rapidly. Breaking up the impaction is difficult and is not necessarily followed by less deformity than leaving the case alone, while it may result in fibrous union. It is unnecessary to employ extension in impacted fractures ; the impaction is generally firm, and the parts can be efficiently immobilised by a long Liston's splint applied, as already described, without a perineal band (see p. 371). The patient should be kept at rest for six or eight weeks

and should not be allowed to bear weight upon the limb for three or four weeks afterwards.

Bony prominences interfering with movement are not infrequently met with in these cases of impacted fracture in which the impaction has not been broken up, and in these cases, therefore, the surgeon may find it necessary to cut down and chisel away the obstructing portions of bone.

FRACTURES OF THE GREAT TROCHANTER.

The great trochanter is sometimes, but very rarely, broken off without any solution of continuity occurring between the shaft of the femur and the neck.

The detached portion is carried upwards and backwards by the muscles attached to it, and the separation is marked, if the fibrous structures be torn through completely ; it may then be impossible to bring the fragment into position in any way except by operation. A stereoscopic radiogram will reveal the site and extent of the fracture.

TREATMENT.—A curved incision should be made over the great trochanter with its convexity forwards, and a flap thrown backwards so as to expose the fractured process ; the limb is fully abducted so as to relax the glutei, and the fragment pulled into position and secured firmly by screws or plates (see p. 305). The limb is placed in a position of abduction and retained there by sandbags, whilst a long splint is applied to the sound side to prevent movement of the trunk. When the wound has healed, the limb is put up in a plaster of Paris spica in the abducted position. The patient should be kept horizontal for about six weeks, and may then be allowed to bear weight upon the limb. There should be no difficulty in obtaining a perfectly useful limb.

FRACTURES OF THE SHAFT OF THE FEMUR.

The shaft of the bone may be fractured by direct or indirect violence in any situation, the most common being just above the centre. The line of fracture from direct violence is generally transverse, whilst that resulting from indirect violence, such as a fall upon the knee or the foot, is oblique or spiral.

FRACTURES JUST BELOW THE LESSER TROCHANTER.

In these fractures the upper fragment is generally tilted forwards, rotated outwards, and somewhat abducted by the pull of the psoas and iliacus. The lower fragment is drawn upwards behind the upper, and is usually pulled slightly inwards by the adductors ; it is rotated outwards by the weight of the limb.

TREATMENT.—The displacement of the short upper fragment

cannot be overcome by traction; the lower fragment must therefore be brought into a line with the upper. The thigh is flexed until the axis of the lower fragment coincides with that of the upper, and the lower fragment must also be abducted and rotated slightly outwards, so as to bring the two fragments into accurate alignment.

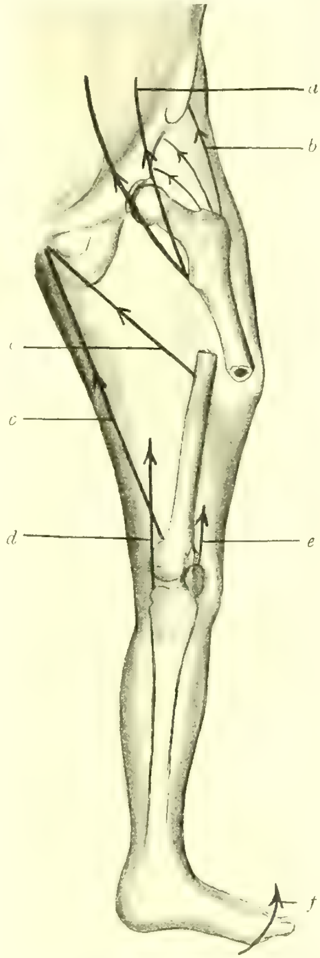


FIG. 186. — FRACTURE OF THE SHAFT OF THE FEMUR. To illustrate the line of action of the muscles producing the deformity. *a*, Ilio-psoas; *b*, glutei; *c c*, adductors; *d*, hamstrings; *e*, quadriceps extensor cruris; *f* indicates how the weight of the limb tends to produce eversion.

It is, however, often very difficult to do this satisfactorily by splints, and therefore, unless there is some strong contra-indication, the best method of treatment is by operation. However well a splint may be applied in the first instance, it will soon be found that the thigh has sagged down and that the rotation has altered, and it frequently happens that the fracture unites at an angle and with one fragment rotated upon the other.

Operation.—The seat of fracture is exposed by an incision along the outer side of the thigh and the fragments are got into accurate position and fixed there by means of Lane's plates (see p. 307). A long Liston's splint will keep the parts steady afterwards, and will be the most comfortable arrangement.

Splints.—When for any reason operation is not advisable, splints must be used. Two forms of splints are in general use for this purpose, viz. Hodgen's and Macintyre's.

Hodgen's splint is applied as follows: A stirrup is first applied to the limb in the usual manner (see p. 274), and then the wire frame, of a size suitable for the particular case, is converted into a form of sling for the reception of the injured limb. Strips of stout flannel of suitable length, and about three or four inches wide, are fastened to one side of the frame, and the latter is then placed in position over the limb and converted into a sling by bringing the free end of each strip of flannel round beneath the limb in succession, and fastening it to the opposite side of the frame, in which the limb is thus suspended comfortably. The upper and outer extremity of the wire frame should lie

just above the anterior superior iliac spine without actually touching it, while the upper and inner end is well up in the fold of the groin; the limb is fastened to the foot of the frame by a cord passing from the stirrup. The fracture is now reduced and the fragments are kept in position by raising the wire frame with the limb in it, and suspending

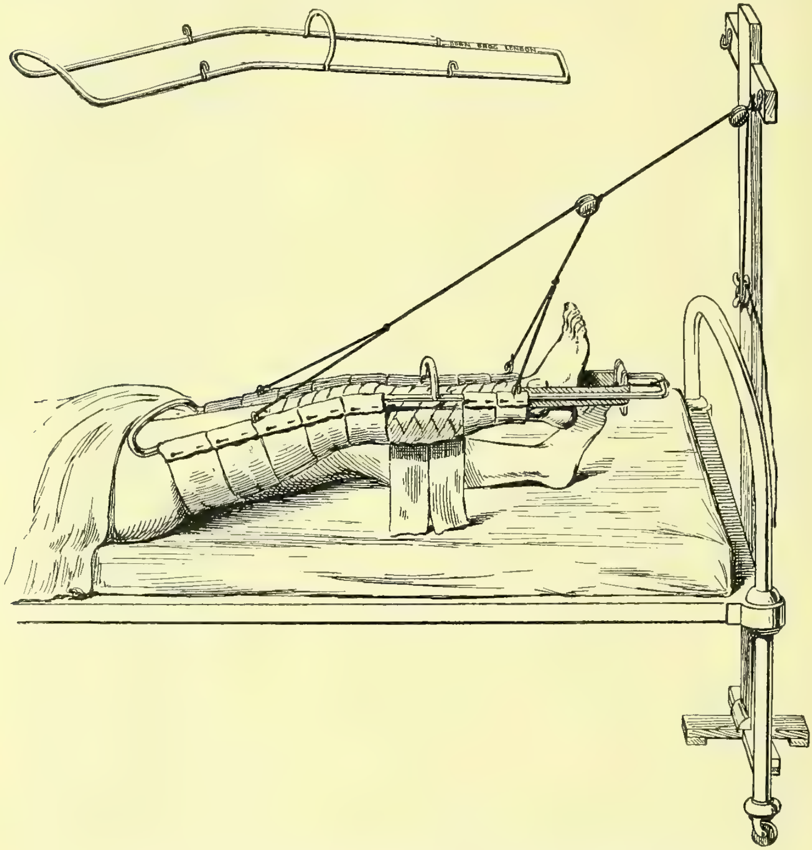


FIG. 187.—HODGEN'S SPLINT. The limb is seen secured to the foot of the wire frame (the shape of which is shown separately in the small figure above) by means of a stirrup secured to the frame by a cord. The method of making the wire frame into a cradle or sling by means of strips of stout flannel is also indicated. These strips are stitched to one side of the frame and then brought round beneath the limb one by one and pinned to the opposite side. Two of these strips are seen unfastened in the figure.

it to an upright at the foot of the bed, which is so arranged that the limb is somewhat abducted and rotated outwards. The method of arranging the suspension cords is seen in Fig. 187.

The limb and splint which are fastened to the top of the upright pillar may be considered as a pendulum which has been drawn aside from its position of rest to which it tends to return. The tendency is,

therefore, for the leg to swing towards the upright pillar and in this way extension is maintained. The heavier the bob of the pendulum the stronger is its tendency to return to the rest point ; hence the heavier the limb, the greater is the force, by virtue of which it tends to swing towards the upright pillar, and, therefore, if more extension be required, the weight of the limb should be increased by adding weight to the

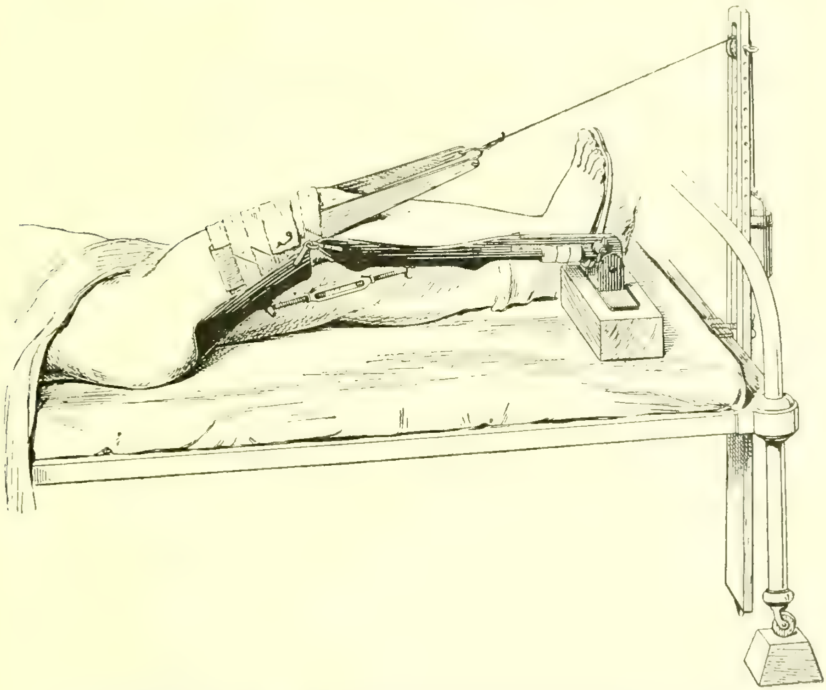


FIG. 188.—WEIGHT EXTENSION FOR FRACTURE OF THE FEMUR BELOW THE TROCHANTERS. The extension here is made in the long axis of the femur, which coincides with that of the upper fragment. The limb is not bandaged to the splint.

metal frame, and not by making greater tension upon the suspending cord.

This splint gives very fair results, and is more comfortable than any other ; the patient can move about in bed to a certain extent, as the splint follows the movements of the body, and he is able to raise himself into the semi-recumbent position without disturbing the fracture unduly. It is the most useful splint for fractures just below the lesser trochanter. It should be kept on for about six weeks and massage may be applied while the limb lies in it. It may be then replaced by a plaster of Paris spica, and the patient allowed to get about on crutches (see p. 373) ; a month later he will probably be able to walk with the aid of sticks.

Another arrangement that may be employed is a *MacIntyre's splint* directed somewhat away from the middle line, bent at the knee, without a foot-piece, and raised sufficiently to bring the fragments into line. The leg should lie on the splint with the foot somewhat everted and not bandaged to it (see Fig. 188). Weight and pulley extension, ranging from five to ten pounds according to the muscularity of the patient, is then applied in the long axis of the thigh by means of strapping around the latter.

FRACTURES NEAR THE CENTRE OF THE SHAFT.

In these fractures the upper fragment is also pulled forward but not nearly to so great an extent as in the fracture higher up. The lower fragment is drawn upwards and backwards behind and rather to the outer side of the upper; this produces a well-marked bowing forwards and outwards of the thigh (see Fig. 186). There is generally considerable shortening.

TREATMENT.—**In Adults.**—In our opinion immediate operation upon fractures of the shaft of the femur should be resorted to much more frequently than is usually the case. Shortening of the limb in adults is a great disadvantage and can be completely avoided by operation, whilst it is rare to get much less than three-quarters of an inch of shortening even after the most careful treatment with splints. Moreover, even when the ends of the bones have been brought into apposition, angular deformity may occur, and this constitutes a disability and is, of necessity, accompanied by shortening. Therefore, when a radiogram shows that the surgeon has failed to interlock the fragments after a thorough attempt under an anæsthetic, he should operate at once. Even if he has succeeded, the case must be carefully watched, to see that no angular deformity occurs, and that the fragments do not slip out of place again. Either of these accidents should be an indication for immediate operation. Delay only serves to increase the difficulty of the case, as the muscles and fasciæ around the seat of the fracture rapidly become shortened and infiltrated, and this renders the task of getting the fractured ends into apposition much more difficult.

Operative Methods.—A special assistant is always required in these cases to manipulate the leg and to exert traction upon it. Counter-extension may be maintained by another assistant, or by a well-padded perineal band attached to the top of the operating table. The strictest antiseptic precautions are imperative throughout, as the least defect in this respect may lead to deep-seated sepsis of a disastrous nature. The limb should be shaved and disinfected from the groin to the ankle, front and back, and all but the intended area of operation should be closely enveloped in sterile towels. The incision, which will be best planned after ascertaining by means of a stereoscopic radiogram what is the most direct route by which to approach it, will generally be made along

the outer side of the thigh. It should be long enough to expose the fragments thoroughly, and all the incisions in the deeper parts should be of the same length. When the clot has been turned out and the fractured ends are exposed, extension is made, and the broken surfaces are manipulated into position and fixed by two or three Lane's plates (see p. 307). Hæmorrhage is then arrested and the wound closed by two layers of sutures, the inner drawing together the fascia lata and the contiguous muscle fibres (see Fig. 129), and the outer uniting the skin.

The limb must be most carefully steadied during and after the mechanical fixation, and immobilisation must be maintained until the splints have been put on. We use for this purpose four short Gooch's splints, folded round the limb; a Croft's plaster casing also answers well. In addition, a long Liston's or a Thomas's hip splint should be

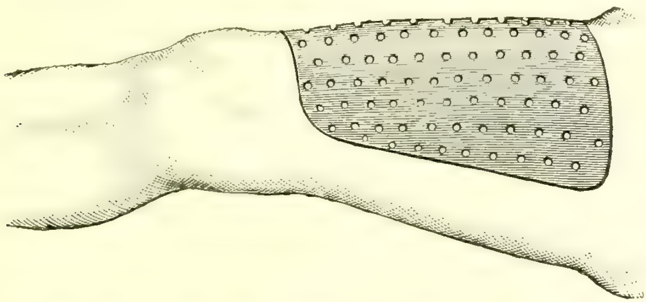


FIG. 189.—METAL SPLINT FOR FRACTURE OF THE SHAFT OF THE FEMUR. This splint may usefully be employed to press down the upper fragment in place of, or in addition to, the plaster of Paris shield, which it closely resembles in shape. Extra weight can easily be added by moulding a sheet of lead outside the splint. This splint is used in addition to the weight-extension.

put on, and in vigorous adults it may be necessary to use extension for the first week or ten days so as to steady the muscles; four or five pounds is sufficient. These fractures require from eight to ten weeks for union to occur.

Non-operative Treatment.—After the fracture has been reduced under an anæsthetic, extension must be employed to prevent subsequent displacement, and in an adult with strong muscles as much as twelve or fourteen pounds is sometimes necessary. The following is a good arrangement. The limb, with an extension stirrup applied (see p. 275), is placed horizontally upon the bed, and a weight of seven or eight pounds is attached to the cord. Counter-extension is provided for by a well-padded perineal band fastened to the head of the bed, the foot of which is raised on blocks. In two or three days the weight may be increased if necessary, up to twelve pounds or more. The limb should be kept parallel with the middle line of the body and eversion of the foot must be corrected, because in these cases the upper fragment is not markedly abducted or rotated outwards. Eversion is best prevented by the means

recommended on p. 379. The question of abduction or rotation outwards of the upper fragment is easily determined by noting the direction of the outer surface of the great trochanter; the position of the lower fragment must be arranged accordingly. When there is marked tilting forwards of the upper fragment, a shield of plaster of Paris may be applied over the front of the limb so as to press the fragment back into position. The shield is made of a layer of house flannel, broad enough to cover the whole of the front of the limb, and plentifully smeared with plaster so as to increase its weight; if necessary, the pressure may be increased by moulding sheet lead and laying it upon the splint (see Fig. 189). If the patient be restless, it may be necessary to put on a long Liston's splint in addition. This should never be done, however, unless it be absolutely necessary, as it materially interferes with the extension, and much heavier weights must be employed if it is used.

It is well to take a stereoscopic radiogram a day after the injury, in order to see the position of the fragments; any shortening can be ascertained by measurement. Some shortening is inevitable, but the weight extension must be increased if it exceeds half an inch. When heavy weights have to be employed, the strapping applied to the thigh often slips and gives rise to troublesome ulceration. In order to avoid this, the leg and foot may be put up in lateral poroplastic or Croft's splints reaching above the knee, and the extension attached to this. A still simpler method is to fasten the extension to a boot; very powerful extension indeed can be then applied without fear of its slipping or causing ulceration. Of course, if the weight necessary to produce effectual extension be so great as to cause pain from undue stretching of the ligaments of the knee, this method is useless; an attempt may then be made to keep the fragments in position by means of a Hodgen's splint, and if that fails operative interference will be essential if a good result is to be obtained.

In Children.—In very young children it is extremely difficult to treat these fractures satisfactorily with the limb in the horizontal position. Any apparatus rapidly gets soiled and requires changing, while the smallness of the limb renders it difficult to secure a splint properly, and, therefore, the fracture does not remain at rest. Even plaster of Paris and silicate casings are open to the same objection, for, although they fix the limb fairly well, they soon get soiled, and become soft and useless, while the skin is irritated and may ulcerate.

Vertical Extension.—In all children under five years of age it is best to suspend the fractured limb in the vertical position at right angles to the trunk. All discharges then pass backwards, there is no possibility of the apparatus becoming soiled, and it is quite easy to keep up efficient extension. A stirrup is applied to the affected limb extending as high as the lower part of the thigh, and to this a cord is fastened which is attached to a bar arranged above the cot or bed, directly over the pelvis, and supported upon two uprights, one at either end of the bed, of sufficient

height to allow of the affected limb being drawn up so that the buttocks are just clear of the bed (see Fig. 190). It is well also to suspend the sound limb to the bar, so that it is impossible for the child to put it on the bed; otherwise he might support the weight of the pelvis upon the sound limb and so nullify the extension. The sound limb, however, should only be raised sufficiently to keep it well clear of the bed, and no actual extension should be applied to it. Both limbs should never be fastened to the same back splint, and vertical extension applied to the latter, as is sometimes recommended. In this method the weight of the pelvis acts as a constantly extending force; there is no necessity to apply any splint, as the child keeps still, and the result is all that could be wished for. The only practical objection to the method is that the stirrup may slip and cause ulceration just above the os calcis. Great care should therefore be taken in applying it, and renewing it as often as may be necessary. A safe way is to put on a boot and make extension from that.

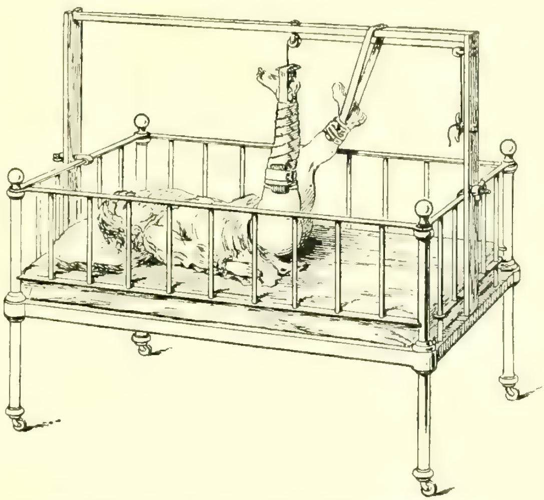


Fig. 190.—Vertical Extension for Fractured Femur in Children. The affected limb is vertical, while the sound one is merely looped up to the bar in order to keep it well off the bed. No splints are required.

Bryant's Double Splint.—In children over the age of five the best splint is perhaps that known as Bryant's. It consists of two long parallel outside splints with bracketted interruptions opposite the trochanter, and connected above and below by adjustable metal bars, which allow for the separation or approximation of the splints according to the breadth of the patient. The sound limb is fastened firmly to the splint by strapping or bandages, while to the injured limb extension is applied, preferably by means of a stirrup,[1] the cord passing round a pulley at the foot of the splint and being fastened to an elastic door-spring (see Fig. 191, *A*), by which the requisite extension is made. A broad bandage or folded

[1] In the double Bryant's splint as originally designed and still supplied by instrument makers, the affected limb is fixed to a foot-piece running in a slot in the lateral splint, and acted upon by the elastic door-spring. This is quite ineffectual in practice, as the foot-piece always jams in the slot and will not slide; a stirrup is much better (see Fig. 191, *B*).

sheet is passed around the upper part of the splint and secures the trunk within it. This splint has the advantage that the child can be turned over, carried about, or wheeled out in the air without disturbance of the fracture.

Mal-union.—It is not uncommon to meet with both mal-union and non-union in fractures of the femur. In the former case there is generally considerable shortening and angular deformity, with the apex directed outwards and forwards. In order to rectify the mal-union the bone may either be re-fractured or cut down upon, and secured in position, the latter being the preferable method.

Operation.—After the limb has been shaved and disinfected with the same scrupulous care necessary for recent fractures, a vertical

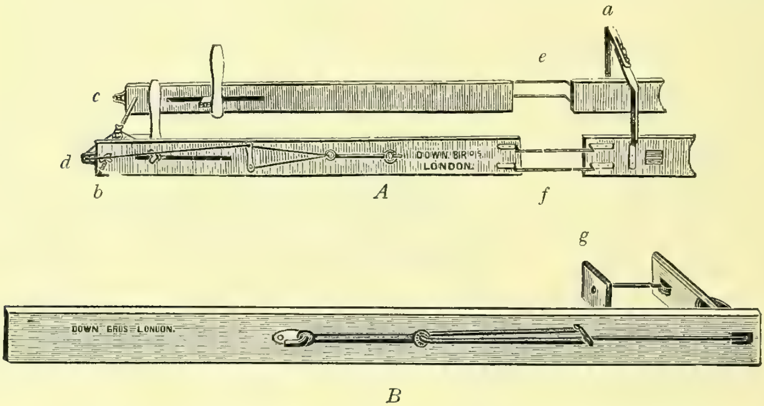
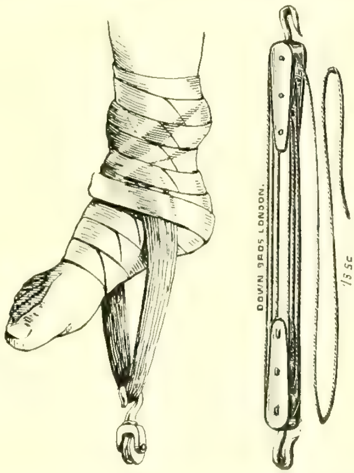


Fig. 191.—The Double Splint for Fracture of the Femur. *A* shows the form originally suggested by Mr. Bryant. The lateral splints can be approximated or separated by the metal bars at *a* and *b*. The sound limb is fastened to the footpiece on the side *c*, while the fractured one is secured to *d*, upon which the extension acts; *e* and *f* are interruptions in the splint opposite the trochanter to allow the limbs to be kept parallel. In *B* is shown the detail of the lower part of one side splint in which extension is made by means of a stirrup which is attached to the piece of wood *g*. This gives more effectual extension, as it cannot jam, as does the footpiece running in a slot.

incision is made over the fracture, generally along the outer side of the limb; this incision should be very free, for if it be too small, the soft parts will be severely bruised in manipulating the bone ends, and this may interfere with the healing. After everything has been cleanly divided down to the fracture, the parts are well retracted and the faulty union is exposed. In nearly all these cases the fracture is oblique, and the line of union should be chiselled through until the fragments are completely separated. The direction of the fracture can often be told with accuracy by means of a stereoscopic radiogram. The periosteum should not be peeled off except in the immediate vicinity of the bone section. Powerful extension must now be applied in order to bring the fragments into position; it may be necessary to employ pulleys, as the traction that can be exerted by even the strongest

assistant is not always sufficient. Before employing the pulleys a stout skein of worsted should be passed behind the ankle, crossed over the dorsum of the foot (see Fig. 192), and bandaged on with a wet bandage to prevent the loop slipping; its end is then attached to the hook of the pulley. An assistant now makes traction upon the pulley, whilst counter-extension is provided for by a perineal band fastened to a hook in the wall or the head of the table. As the extension is made, the tissues in the region of the fracture become tense, and should be divided as they are put on the stretch; it is important to see that no large vessel or nerve is divided. After as much elongation of the limb as possible has been obtained, the extension is maintained whilst any projecting portions of bone are removed by a chisel, and a well-fitting fresh bony surface is prepared on each fragment. It is a good plan to shape the ends of the bones so that, when fastened together, they will interlock and so resist the tendency of the muscles to displace them (see Fig. 193). The bones are firmly fixed together by Lane's plates (see p. 307). In cases of mal-union or non-union accompanied by considerable shortening all the surgeon's efforts may fail to reduce the shortening materially and the best result obtainable, will be firm union with a shortened, but straight bone. This, however, will give the patient a useful limb instead of one that seriously impairs his power of locomotion.



A *B*

Fig. 192.—Method of Attaching Pulleys to the Lower Extremity. In *A* the skein of worsted is passed round the ankle; the ankle has been previously bandaged, to prevent abrasion. The whole is then wetted, and a wet bandage is applied outside the skein of worsted to prevent it slipping when the pulleys *B* are attached to the loop below the sole.

The after-treatment is similar in all respects to that described for operations upon recent fractures in this situation (see p. 385).

Non-union.—The operative procedure for cases of ununited fracture is essentially the same. Care is taken not to peel off the periosteum to a greater extent than is absolutely necessary, and the line of fracture is refreshed by chiselling enough off the end of each fragment to get a raw bony surface exposed. The fractured ends are secured as recommended above.

After-treatment.—It must be remembered that union after operation in cases of non-union is often slow, and that at least twelve weeks will be required before consolidation is likely to be complete, and it may be six months or more before firm union occurs. Hence care must be taken to keep the parts at rest for a sufficiently long period. The

administration of thyroid tabloids and the use of massage and Bier's treatment are said to hasten consolidation.

The immobilisation should be carried out at first in an exactly similar manner to that for cases of recent fractures that have been operated upon (see p. 385). After the wound has healed, a useful apparatus is a plaster of Paris casing around the limb from the calf to the groin, in which is incorporated an outside straight wooden splint reaching up to the axilla, with a bracketted interruption opposite the trochanter. The upper part of the splint is fastened to the thorax by a sheet or a broad bandage. A plaster of Paris splint alone, which does not extend higher than the groin, cannot be recommended. The limb shrinks inside the splint and the grasp on the upper fragment becomes so imperfect that movement is sure to occur at the seat of fracture. If a plaster of Paris casing be employed alone, it must certainly be carried around the pelvis, and even then its grip is not satisfactory. If the case goes on for more than two or three months without firm union occurring, and if it be desirable for the patient to get about, a Thomas's hip-splint with a second bar along the inner side of the thigh and leg, or, better still, a Hessing's splint, should be employed. Both of these allow massage to be practised, which is of the greatest value at this stage.

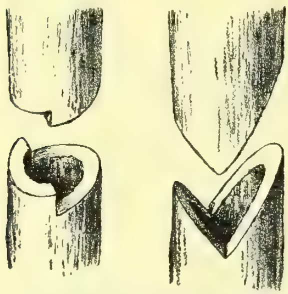


Fig. 193.—Methods of cutting the Femur for Ununited Fracture. Two methods are illustrated, but others may be employed. Either involves some slight shortening o the limb, but this is compensated for as there is much less tendency for the fragments to be separated afterwards by muscular action.

Compound Fractures.—An attempt should always be made to save the limb, if at all feasible ; the treatment will be the same as that already given for compound fractures elsewhere (see p. 283). The opportunity should be taken to fix the ends of the bones together (see p. 305). Ample drainage must be provided. Union is often slower in these cases than in simple fractures, and consequently a long period of immobilisation may be necessary.

FRACTURES OF THE LOWER END OF THE FEMUR.

The chief fractures in this situation are supra-condyloid fracture, which occurs at a little distance above the condyles ; fracture of either condyle separately ; T-shaped fracture into the joint ; and separation of the epiphysis. All these fractures, except the supra-condyloid form, necessarily involve the joint cavity.

SUPRA-CONDYLOID FRACTURE.

This fracture is due either to direct or indirect violence ; in the former case the line of fracture is usually more or less transverse, but after indirect violence, such as falls upon the knee, its direction is generally oblique.

Fracture usually occurs from one and a half to two and a half inches above the epiphyseal line, and its direction is oblique from above downwards and forwards. The consequence is that the lower fragment is always behind the upper, and, as the gastrocnemius and the popliteus muscles are attached to the lower fragment, the latter is tilted back so that its fractured surface looks somewhat backwards into the popliteal space. In some cases this projection is so great that serious pressure occurs on the contents of the popliteal space ; indeed the popliteal artery may be punctured by a sharp fragment, or may be entirely torn across. When the artery has been injured, there may also be a diffuse aneurysm or so great an extravasation of blood into the ham as to lead to occlusion of the vessel from pressure. Apart, however, from rupture of the artery, the pressure of the lower fragment upon it may lead to gangrene of the limb below, especially if reduction of the fracture be not effected. The upper fragment lies in front of the lower, and its lower end is usually directed towards the inner side of the knee ; its sharp lower end may perforate the synovial membrane of the knee and lead to effusion of blood into the joint.

TREATMENT.—It is difficult to obtain a thoroughly satisfactory result after this injury without operation ; the backward rotation of the lower fragment renders it difficult to get the broken ends into proper position, while adhesions are likely to form, and a stiff joint not infrequently follows. An anæsthetic should be employed in setting the fracture and, if possible also, the X-rays. Immediate operation should be always resorted to if perfect coaptation cannot be secured.

Hodgen's Splint.—As the lower fragment cannot be brought into line with the upper by horizontal traction, the fracture must be put up with the knee and thigh flexed ; extension will also be required to pull down the lower fragment. For this purpose a Hodgen's splint (see p. 382) with the wire frame bent beyond a right angle at the knee may be employed. Many cases, however, require greater flexion and must be put up on a double inclined plane at a very acute angle.

MacIntyre's Splint.—After three or four weeks a MacIntyre's splint, bent at a considerable angle, may be used until consolidation has taken place, which will be in six to eight weeks. Fractures in this region are essentially those in which careful massage and passive movement are desirable. They should be employed from the commencement on account of the great tendency to stiff knee. For a description of the method see p. 280. If the knee-joint has been punctured by the upper fragment,

adhesions are very likely to occur ; if these be allowed to become firm, the treatment will be much more difficult, as they can only be overcome at a late stage by forcible movement, followed by massage and passive motion.

Operation.—Even with the greatest care, however, these fractures are apt to give unsatisfactory results, and in most cases the best treatment is undoubtedly operative. It may be laid down as a good rule that a radiogram should be taken as soon as possible after the reduction of the fracture, and, should this show that the bones are not in proper position, the fracture should be cut down upon. The incision should be made at the outer side of the limb, and care should be taken to avoid opening the knee-joint if possible, by keeping well to the side. When the fracture has been exposed, the broken ends are manipulated into position while an assistant makes extension, and the ends are fastened together by lateral bone plates (see p. 307). The limb is then placed on a MacIntyre's splint without any extension, the knee being flexed. Massage and passive movement may be begun in ten days with a view of preventing adhesions, care being taken to fix the fragments with both hands while the movements are being carried out.

Compound Fracture.—When these supra-condyloid fractures are compound, special investigation must be made in order to see whether the knee-joint is wounded. The wound should be laid freely open, the usual methods for disinfection employed, and the fragments fastened together (see p. 305). If the joint be wounded, the opening into it should be enlarged sufficiently to enable it to be washed out, if it contains blood and clots. Drainage tubes should be inserted for the first two or three days. The limb is put up in a MacIntyre's splint and the after-treatment, already described, carried out (see p. 391) if no septic infection occur. Should sepsis occur, the question of amputation will arise. If the condition be serious, there should be no delay in resorting to it, because septic osteo-myelitis will complicate the acute suppurative arthritis.

FRACTURE OF EITHER CONDYLE.

Either condyle may be detached by a fracture which passes obliquely downwards and inwards or outwards according to the condyle affected.

TREATMENT.—Great care must be taken to get the fragments into position. In the great majority of cases this is best done by immediate operation. If for any reason operation is out of the question, reduction should be attempted by manipulation under an anæsthetic and the limb should be fixed on a suitable splint. If there be any backward tilting of the detached condyle, a MacIntyre's splint is best; but if not, the limb may be placed in the extended position in a Croft's splint. A stereoscopic

radiogram should be taken immediately, in order to see whether the joint surfaces are in proper alignment ; if they are not, operation is absolutely necessary. The incision should be made at the side of the joint, avoiding the synovial cavity if possible, and the fragment is got into position and fixed by pegs or long screws driven through the condyle, or by Lane's plates. If there be much effusion, it is well to make an incision into the joint, wash out the clots, and close it again without a drainage tube. Unless operation be performed within a very short time of the injury, it will be extremely difficult to get the fragments into position.

After operation the limb should be put in a Croft's splint ; massage and passive movement are begun after about ten days, and the splint is kept on for at least four or five weeks.

T-SHAPED FRACTURE INTO THE KNEE-JOINT.

This is a severer form of the preceding injury and corresponds to a T-shaped fracture of the lower end of the humerus.

TREATMENT.—It is scarcely possible to obtain satisfactory movement of the knee in these cases without operation. An incision should be made on each side of the joint, the condyles exposed, manipulated into position, and pegged to one another by means of long ivory pegs or screws (see p. 305). Before drilling the condyles for this purpose, the finger should be introduced into the joint so as to ascertain that the two condyles are in position. All blood-clot is washed out of the cavity of the joint and any small loose fragments taken away. After the condyles have been united to each other, the articular end of the bone is secured to the shaft by means of plates. The operation is difficult, as satisfactory access to the line of fracture is hard to obtain without opening the joint freely. There need be no hesitation in doing what is necessary, however, as the result is sure to be very poor if accurate adaptation be not obtained.

After-treatment.—This is similar in all respects to that advised for the preceding group of cases (*vide supra*). In spite of early operation and accurate adaptation of the fractured surfaces, the prognosis as regards restoration of function in the knee-joint is not very good, owing to the severe damage inflicted upon the structures in the neighbourhood of the joint and the adhesions that are likely to result. Special attention must be paid to the efficient performance of massage and passive motion from an early stage, while at the same time all movement about the fracture is avoided (see p. 280).

SEPARATION OF THE LOWER EPIPHYSIS.

This is a comparatively rare occurrence ; the injury always necessarily involves the knee-joint and is often associated with defective development of the bone afterwards. It generally occurs from forcible over-extension of the knee and, consequently, the epiphysis is carried forward in front of the lower end of the diaphysis, which is pressed backward, and may exert dangerous pressure upon the popliteal artery. The injury is often compound.

TREATMENT.—Recent researches, particularly those of Hutchinson and Barnard,[1] seem to show that this particular injury is best treated by full flexion of the knee without the use of any splint. Their description of the method is as follows :

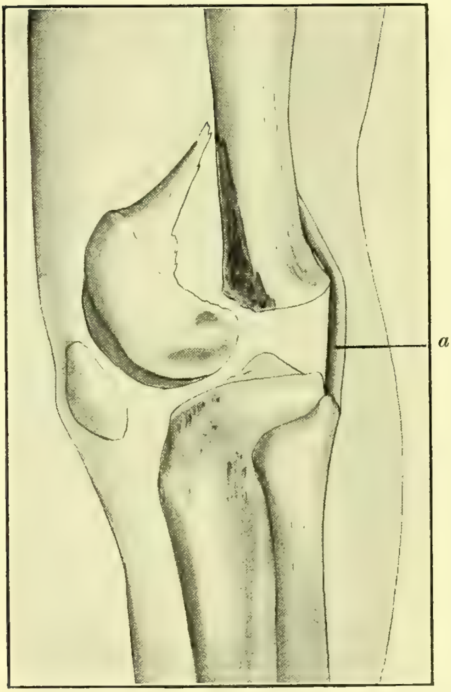


FIG. 194.—SEPARATION OF THE LOWER EPIPHYSIS OF THE FEMUR. *a*, The popliteal artery stretched over the lower end of the upper fragment.

'Under complete anæsthesia an assistant makes steady but strong traction upon the tibia in the line of the limb. This overcomes the upward pull of the quadriceps extensor and brings the epiphysis down to the line of separation. The operator then clasps his hands beneath the lower part of the thigh, and draws it steadily upwards, gradually flexing completely the knee and hip-joint, whilst the assistant still keeps up the traction on the leg. It will be seen that this manœuvre causes the epiphysis to move back upon the fractured surface of the diaphysis until it has reached its normal position, and further movement is prevented by the periosteum coming into tight contact with the anterior surface of the femur.

'A bandage is then applied around the thigh and ankle, fixing the knee at about an angle of 60°. Complete flexion—*i.e.* heel on buttock—we have found to be unnecessary, and the wider angle is more comfortable. The limb is laid upon its outer side on a pillow, and an ice-bag can conveniently rest uopn the front of the knee to limit the effusion.'

[1] *Lancet*, May 13th, 1899.

In about a fortnight's time the limb is moved, preferably under anæsthesia, and then put up in a Croft's splint at an angle of 150°. Passive movements and massage will be required from this time onwards.

Operative interference may be called for in these cases. The seat of the fracture is best exposed through an external incision. Reduction of the displacement is effected by flexing the limb at the knee and hip, and making traction in the line of the bone. The fragments are manipulated into position, and fixed with screws and plates or with a staple. The exact method will depend upon the shape of the lower fragment, as the plane of separation rarely corresponds to the epiphyseal cartilage throughout its whole extent. Some surgeons recommend that the plate or staple should be removed as soon as union is complete, so as to avoid interference with growth. The after-treatment is similar to that of the previous variety (*vide supra*).

Occasionally the sharp edge of the lower fragment injures the vessels in the popliteal space and the leg becomes gangrenous. This complication should be watched for, and treated as for gangrene from any other cause (see Vol. I. Chap. IV.).

DETACHMENT OF ARTICULAR CARTILAGE.

This accident sometimes results from falls upon the knee or the foot. A portion of the articular cartilage with its underlying bone becomes detached from the surface of one of the condyles of the femur and forms a loose body in the knee-joint.

TREATMENT.—If the nature of the injury be made out at the time, as by feeling a loose body moving about in the joint or by a radiogram, the best plan is to do an arthrotomy at once and remove it. If the operation be long delayed, the loose body sets up considerable changes in the synovial membrane, leading to the formation of firm adhesions and sometimes a villous condition of the synovial membrane not unlike that seen in osteo-arthritis. The loose fragment rarely becomes united to the bone; if it does, it is in wrong position, and for this reason also the sooner it is removed the better. The details of the operation are described fully in connection with loose bodies in the knee-joint (see Vol. III.).

CHAPTER XX.

FRACTURES OF THE PATELLA.

FRACTURE of the patella is of common occurrence and great importance. The line of fracture may be either transverse, longitudinal, or starred; the most frequent form is the *transverse fracture,* which usually results from violent muscular action, as when an attempt is made to recover the balance. The knee is bent and the quadriceps extensor is thrown into such violent contraction that the patella is snapped across the condyles of the femur. The fracture is generally transverse, but in some cases it may be oblique from below upwards and backwards, and it usually occurs nearer the lower than the upper end of the bone; sometimes only a small fragment of bone is left attached to the ligamentum patellæ.

Fractures produced by direct blows upon the patella are very often *starred,* the bone being broken up into several pieces. Sometimes, however, they are *longitudinal,* the patella being divided into two unequal lateral portions. In neither of these cases is the separation of the fragments so marked as in the transverse fracture.

TRANSVERSE FRACTURE OF THE PATELLA.

There are four points of importance in connection with this fracture. In the first place, the separation of the fragments depends upon the tearing of the periosteum and the capsule at the sides of the bone; it is generally sufficient to allow the finger to be introduced between the fragments when the knee is flexed. Unless measures be taken to prevent it, the upper fragment becomes more drawn up as time goes on, until there may be a gap of several inches between the fragments. The second and, perhaps, most important point of all is that the periosteum is not torn across on a level with the line of fracture; it usually gives way below the fracture, and a piece of periosteum projects for half an inch or more beyond the lower edge of the upper fragment, and curls round and lies over the fractured surface (see Fig. 195). Hence this layer of periosteum is interposed between the two fragments when they

are approximated, and this is an important reason why union by bone does not occur except after operation. The third point to remember is that the lower fragment is usually tilted forwards, and, therefore, when the upper fragment is brought down into contact with it, the cartilaginous surfaces do not lie in the same plane. The upper fragment, moreover, may be somewhat tilted, so that the broken surface looks backwards. Fourthly there is considerable laceration of the capsule.

TREATMENT IN RECENT CASES.—It follows from the above considerations that the object of the treatment must be fourfold: the separation must be overcome, the layer of fibrous tissue and periosteum between the fractured surfaces must be removed, the tilting of the fragments must be remedied, and the rent in the capsule must be closed.

Operative.—It is evident that these objects can only be effectually carried out by means of operation. We, therefore, recommend an open operation as the best treatment for recent transverse fractures of the patella.

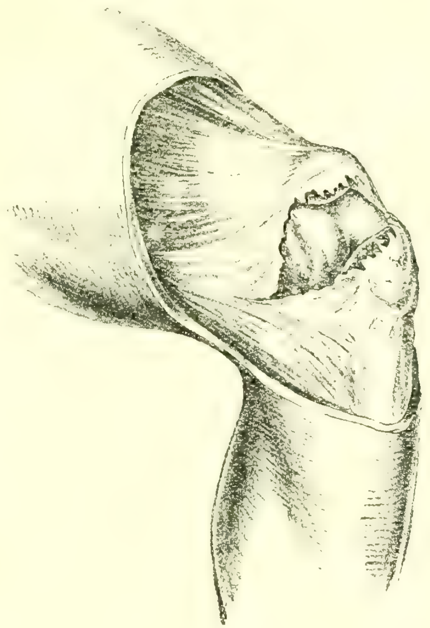


FIG. 195.—TRANSVERSE FRACTURE OF THE PATELLA. The specimen shows the curling-in of the fibrous aponeurosis over the front of the bone, so that the fractured surfaces are partly hidden. (*After Helferich.*)

Advantages of operative treatment.—Sometimes the patient is disinclined to submit to an operation and the decision does not lie with the surgeon. The patient, however, should have the result of treatment in the two cases clearly explained to him. After operation the result is practically perfect restoration of the functions of the limb within a very short time; we have frequently had patients who were able to go about their business within five weeks after the injury without even using a stick. The result depends entirely on the asepsis of the wound; if that can be assured, there is really no risk. On the other hand, progress is extremely slow in cases not treated by operation, and it is often six months or more before the patient can bear any weight upon the limb or can do without some form of apparatus for keeping the fragments together; it is still longer before he can dispense with crutches or a stick. During this time the muscles of the limb atrophy, so that there is a further loss of power, and a very long

time must elapse, even when the fracture is fairly well consolidated, before the patient can get about satisfactorily. At first the movements are feeble, slow and uncertain, partly from the weakness of the limb, partly from want of confidence, and often from adhesions in the joint.

A not uncommon result of fractures treated by non-operative methods is a stiff knee from adhesions which follow upon inflammation and the long rest necessary to obtain close fibrous union. When these adhesions are extensive they are the more difficult to get rid of because the force required to break them down may seriously imperil the ligamentous union. Besides this, the union between the fragments is never bony, and although at first the fibrous tissue may be short, broad and firm, and the fragments closely approximated, the uniting medium gradually stretches with movement and the strain put upon it, so that ultimately there may be a considerable gap bridged across by an elongated thin fibrous band. It is true that cases have been recorded and shown where the patient gets along very well after treatment by splints, udt it must be remembered that such a result is not the rule, that it is only obtained after very prolonged treatment and is never absolutely perfect. The limb is never quite sound, the patient as a rule cannot go upstairs without dragging his leg behind him, he cannot kick, he cannot go down an incline without considerable difficulty, and the fibrous union is always liable to stretch after a time. The results are never as good as when bony union occurs between the fragments.

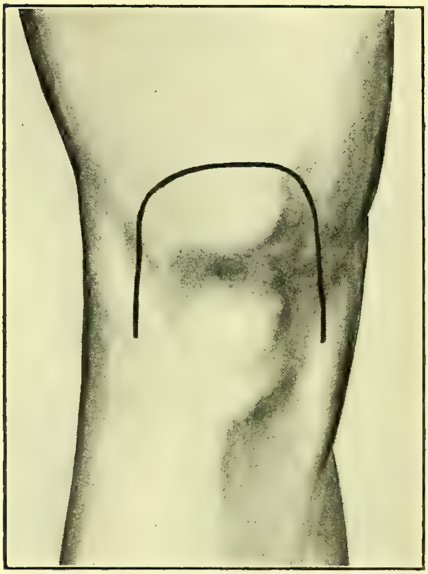


FIG. 196.—INCISION FOR THE OPERATION OF WIRING A TRANSVERSE FRACTURE OF THE PATELLA.

Contra-indications.—These are very few in number. There is no reason why the operation should not be done in a person well on in years; an old patient suffers almost more than a young one from the loss of exercise which is likely to result from the treatment of these fractures by the expectant plan, while the operation is not accompanied by shock, and there is no difficulty in obtaining firm union. Ill-health, heart disease, advanced albuminuria, diabetes, and so forth, naturally contra-indicate the operation; but in an ordinary healthy person, even of 70 or more, there is no objection to the operation.

Time for Operation.—Some surgeons prefer to wait for four or five days for the inflammation and synovitis, set up by the injury, to subside, but we have been in the habit of operating as soon as possible after the accident, and we have seen no reason whatever to regret doing so. Immediate operation has the advantage that it allows movement to be begun at the earliest possible moment and thus gives less chance of adhesions forming, and, moreover, the blood and clots are cleared out of the joint at quite an early period.

Incision.—After the skin has been disinfected with especial care,—owing to the coarseness of its structure it is a favourite seat of micro-organisms—a flap should be turned down over the front of the patella. The incision begins about one inch to one side of this bone, a little below the level of the fracture, and is then carried upwards and curved across the front of the knee about an inch above the upper margin of the patella, and is finally brought down on the opposite side to a point opposite its commencement (see Fig. 196). This flap of skin and superficial fascia is turned down until the lower fragment and the ligamentum patellæ are thoroughly exposed. The advantage of this incision over the usual vertical one is great. If a vertical incision be used, the wire uniting the fracture lies immediately beneath the scar, which it is apt to perforate, or at any rate to irritate considerably, when the patient kneels and, should re-fracture occur, the vertical scar is apt to give way and a compound fracture results. When a flap is employed, however, the wire, lying underneath healthy skin, seldom causes trouble ; and, should re-fracture occur, there is no more reason why the fracture should be compound on the second occasion than on the first. It is well to have the convexity of the flap upwards instead of downwards, because if the incision be made downwards the scar will lie over the tubercle of the tibia, which is the point exposed to pressure when the patient kneels.

Clearing the Fracture.—As the flap is turned down and the line of fracture is reached, the rent in the capsule on each side of the bone will be seen, and blood and clots can be pressed out from the joint. After the two fragments have been exposed, the fractured surfaces are everted and inspected, and the periosteal layer which is curled over the surface of the fragments (see Fig. 195) is peeled back. It need not be cut away, because it is well to stitch it over the line of fracture afterwards, but it must be removed from contact with the fractured surfaces. Any blood clot in the joint or between the fractured surfaces should be removed very carefully.

Drilling the Bone.—When the surfaces have been prepared thus, the upper fragment is bored for the passage of the wire. The best instrument for drilling the patella is a square bradawl or 'reamer' ; this is less likely to split the bone than the ordinary form, but whatever form of awl be employed it must be used gently and well rotated ; it should be allowed to work its way through the bone and must not be

forced onwards. A small vertical incision should be made through the fibrous structures down to the bone at the point where the bradawl is to be introduced, and each side of this incision should be seized by a pair of catch forceps, so that the edges of the aperture can be held aside, and thus the end of the wire does not get entangled and the opening of the drill hole is not lost (see Fig. 197). The instrument should be entered at the centre of the anterior aspect of the bone, as far away from the fractured surface as possible, and driven obliquely through it, so that the point will emerge just in front of the articular cartilage.

FIG. 197.—WIRING THE PATELLA. *Drilling the lower fragment:* The catch-forceps are seen retracting the edges of the slit in the soft parts over the bone. The wire has been passed through the upper fragment. For the sake of clearness the fingers which push up and steady the lower fragment while it is being drilled are not shown.

Passing the Wire.—After the upper fragment has been bored in this manner, a piece of silver wire, about a tenth of an inch in thickness (known as No. 4 French catheter gauge), and quite soft and flexible, is passed through the hole. The point on the fractured surface of the lower fragment corresponding to the point of emergence of the wire through the upper one is then carefully ascertained, and a drill is driven downwards and forwards from this point through the lower fragment until it emerges from its anterior surface just at the attachment of the ligamentum patellæ. At the point where the drill emerges, the soft parts are divided vertically and the edges of the incision are caught and held aside with

catch forceps (see Fig. 197). The drill is then removed, and the lower end of the wire is pushed through the aperture in the fractured surface of the lower fragment and made to emerge between the forceps. In order to facilitate the passage of the wire, the knee should be flexed to increase the gap between the fragments and a good long loop of the wire pulled out between them (see Fig. 198). This method of drilling the lower fragment from the fractured surface downwards and forwards to the anterior surface is much preferable to that often adopted of drilling upwards and

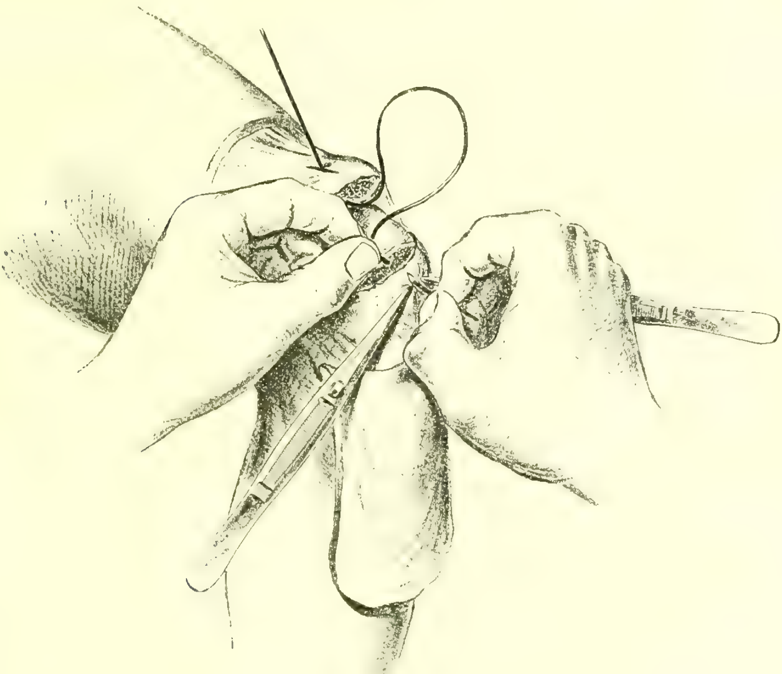


FIG. 198.—WIRING THE PATELLA. *Passing the wire.* The knee is well bent and a long loop of the wire is pulled out and the lower end passed through the lower fragment from the fractured surface.

backwards from the anterior surface and making the point of the drill emerge on the fractured surface, as is done in drilling the upper fragment. The method we describe renders it much easier to ensure the correspondence of the two drill holes on the fractured surfaces—a point of vital importance in securing accurate apposition and a good functional result.

Fastening the Wire.—The wire is seized with strong forceps and pulled through and straightened by pulling firmly upon its two ends. It is held quite taut, and the fragments are pushed together over it by an assistant, while the limb is fully extended, great care being taken to see

that the two cartilaginous surfaces come into accurate apposition. The wire is then bent up so as to approximate the bony surfaces, several twists are made in it (see Figs. 199–200), and its ends are cut off by cutting pliers and hammered down so that there is no projection on the surface of the bone. Care must be taken to see that each end of the wire rotates round the other when it is twisted up, and not that merely one wire is twisted round the other, as in that case movement would pull the inner wire out. Each wire must be held out parallel to the surface of the bone and rotated equally.

When a vertical fracture of the lower fragment is met with in addition to the transverse one, the surgeon should begin by uniting the two halves of the lower fragment with medium-sized wire, and then the fragment

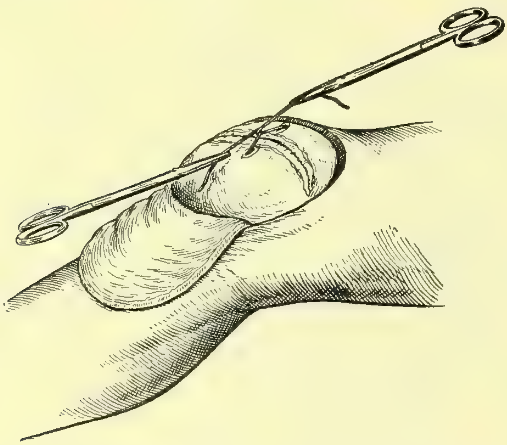


Fig. 199.—Wiring the Patella. *Twisting the wire.* The limb is straightened, the wire pulled taut and twisted. The rent in the capsule is then stitched up, and the flap replaced and sutured.

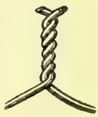


Fig. 200.—Method of Twisting the Wire when Uniting a Fractured Patella.

thus united is secured to the upper one by means of two vertical wires, one for each half of the lower fragment (see Fig. 201).

The loose periosteum is next stitched with catgut over the seat of fracture, and one or two stitches through the rent in the capsule on either side complete the operation. The skin-flap is fastened in position by a continuous silk suture ; no drainage tube is necessary. A considerable mass of dressing should be bandaged firmly around the knee to keep the joint still without the aid of a splint. The patient is put back to bed with the limb slightly elevated upon a pillow.

After-treatment.—The chief point in the after-treatment is to restore the movements of the joint as soon as possible, so as to avoid the occurrence of adhesions. For this reason we think that no splint should be applied. Formerly we used splints for some weeks, but we then found that there was stiffness which required much patience to overcome.

Since we have abandoned the use of splints we are much better satisfied with the results. The dressings are removed at the end of a week, the stitches taken out, and a thin layer of gauze laid along the line of the incision and fixed on with collodion. The leg is then left free and the pillow removed, while the patient is encouraged to move the limb as he chooses. No restriction is placed on the movement that he may carry out in bed. At the end of a fortnight he is permitted to stand with the aid of a couple of sticks and to bend the knee from time to time. At the end of three weeks he is allowed to get about with the aid of two sticks, and by the end of six weeks he is usually able to walk without support, and has perfect movement of the joint. There is no reason why the patient should not be allowed to walk about early, relying on the silver wire alone; if it be strong enough and has sufficient hold, it may be trusted to keep the parts properly in apposition until bony union has taken place.

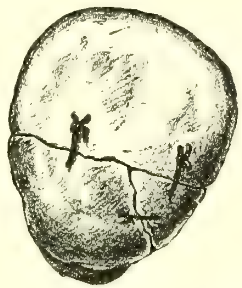


FIG. 201.—METHOD OF UNITING A COMMINUTED FRACTURE OF THE PATELLA. The two smaller fragments are united by a thin wire, and the single fragment thus produced is united to the other by two stout wires.

The wire gives no trouble afterwards if the flap operation be employed. Formerly, when a vertical incision was employed, the wire sometimes caused a good deal of irritation to the scar and had to be removed. If it be necessary to remove the wire, a small vertical incision should be made over it rather to one side and near the twist, the wire divided by cutting pliers close to the bone, and then the long end pulled upon until it is extracted. When the wire is very thick this is sometimes difficult, and then it is best to make a rather longer incision over the wire, cut it just to one side of the twist, and then seizing each end with a forceps to straighten the wire as much as possible. Then one end is cut off close to the bone and traction is applied to the other, and the wire drawn through without difficulty. The wire should not be extracted until some months after the operation, when it is quite certain that consolidation is complete.

Other Operations.—Other operative measures have been introduced with the idea that they offer greater safety to the patient. In our opinion none of them are nearly as satisfactory as the one just described. Malgaigne's hooks are used by some, and a subcutaneous operation, upon the lines of that devised by Mr. Barker, by others. But the objection to them all is that, even if they succeed in securing perfect adaptation of the fragments, which is doubtful, the torn periosteum and fibrous tissue are still left interposed between the fragments and offer a bar to proper union. If the surgeon's work be aseptic there is no more danger in the open operation than in the others, whilst the result obtained by it is much more satisfactory.

A good many surgeons unite the fragments by means of one or more

of Lane's bone-plates applied flat over the anterior surface. While this is an excellent method, we prefer to use a wire, as it gets a better hold and is less likely to cause irritation subsequently than are the plates.

Non-operative.—The limb must be put on a splint with the knee fully extended and the thigh flexed as far as possible, so as to relax the quadriceps extensor muscle. This is best done by using a back splint with a foot-piece at right angles and raising it on an inclined plane. The fragments should be brought as close together as possible, and the chief obstacle to this is the effusion into the joint. Free bleeding occurs into the joint as a result of the injury, and later on synovitis with effusion takes place. Until this has been subdued to some extent, the fragments cannot be approximated satisfactorily.

Reduction of the Effusion.—In the first place evaporating lotions, lead and opium lotion, or an ice-bag, should be applied until the effusion has become absorbed. It will often be a week or ten days before any successful attempt can be made to bring the fragments into apposition. If the effusion be considerable, matters may be hastened by *aspirating the joint* with all aseptic precautions, the skin being purified, and the fluid drawn off with a fairly large aspirating needle. The result of aspiration, however, is seldom satisfactory; it is difficult to empty the joint completely, as a great part of the effusion consists of blood-clot which is apt to choke the needle, so that the fluid is only drawn off imperfectly. The removal of a small amount of fluid, however, will hasten absorption considerably by relieving the tension. The needle should not be pushed too far back into the joint, as otherwise it will be thrust into blood-clot, and will get blocked; it should be pushed downwards beneath the front part of the capsule where the fluid has collected. The small puncture is dressed with a piece of gauze fixed on with collodion, and then steps should be taken to bring the fragments together.

Approximation of the Fragments.—The knee is shaved, and the lower fragment is pushed firmly upwards so as to put the ligamentum patellæ on the stretch; the bone is then fixed in this position by a piece of strapping which has its centre over the ligamentum patellæ and the lower fragment, while its ends pass obliquely upwards on either side to be fixed to the edges of the splint. Care must be taken to see that the fragment is in proper position when the strapping is applied, as the object is not only to fix it, but also to prevent the tilting forward of the lower fragment which is so marked a feature, and which might result in the cartilaginous surface of the lower fragment being in contact with the bony surface of the upper one.

After the lower fragment has thus been fixed, the upper one must be brought down into contact with it; this is usually done by applying a broad piece of strapping, or 'elephant plaster,' over the front of the lower part of the thigh, extending from six or eight inches above the upper edge of the patella downwards as far as the line of fracture; it should be cut

away over the patella, so that the edge of the bone is surrounded by a horse-shoe shaped piece of plaster. The plaster is then bandaged to the limb, and tapes are fixed to its free lower end on each side. To these are attached pieces of elastic tubing which are fastened to hooks in the foot-piece of the splint (see Fig. 202). It is well also, especially in muscular or irritable subjects, to immobilise the quadriceps extensor as much as possible by surrounding the thigh with strapping applied obliquely from above downwards. If sufficient extension be applied, the upper fragment of the patella is brought down into contact with the lower.

After-treatment.—This apparatus should be kept on for six or eight weeks and the plaster must be renewed as often as it slips; when this

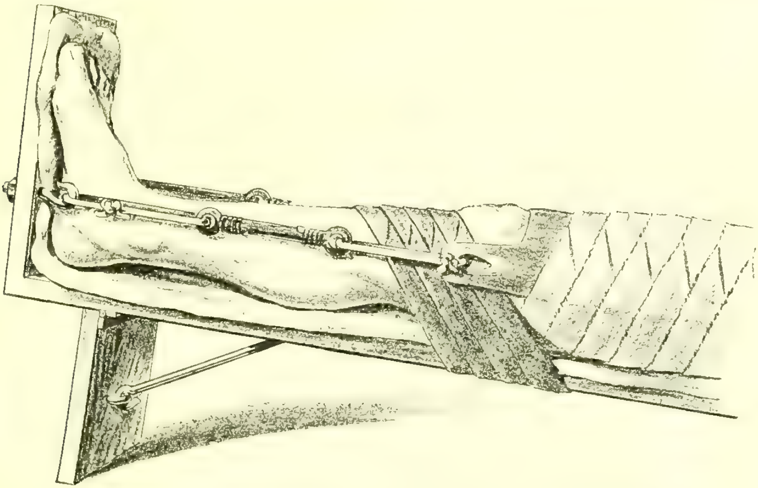


FIG. 202.—FRACTURE OF THE PATELLA TREATED BY SPLINTS. The lower fragment is fixed by oblique strips of strapping fastened to the splint, and the upper one is pulled down by the elastic apparatus shown above, and attached to the horse-shoe shaped plaster bandaged firmly to the thigh.

is done, the opportunity should be taken to employ massage, the upper fragment being held down in contact with the lower by one hand, while massage is carried out with the other. Care must be taken to avoid a pressure-sore around the margin of the patella; a pad of boric lint between the margin of the bone and the edge of the plaster will generally prevent this. The strapping may be removed in about eight weeks, when a certain amount of fibrous union will have occurred, and this will not yield so long as the patient does not voluntarily contract the extensor muscles. Massage should now be applied to the quadriceps in the downward direction so as not to separate the fragments, and at the same time careful movements of the patella should be employed with the view of preventing adhesions. The two fragments must be pressed together while this is being done; the knee-joint may be flexed daily with the same precautions.

A tightly-fitting knee-cap should then be applied and the patient allowed to walk with crutches. Weight may be borne upon the foot at the end of six weeks, but the patient should use crutches for two months longer, and may then take to two sticks. It will generally be nearly a year before these can be dispensed with.

Owing to the great muscular atrophy which follows prolonged treatment by splints, and owing also to the risk of stiffness from adhesions, some surgeons avoid the use of splints, relying upon massage alone. Under this treatment it is held that many cases recover with a satisfactory limb, although with considerable separation of the fragments. This seems a somewhat exaggerated view; and while, on the one hand, it is probably a mistake to keep up the limb for any considerable time without having careful regard to the condition of the muscles or the joint, it seems still more unsurgical to give up all chance of close union. Hence, when operation is not possible or permitted, we prefer the plan that we have just described.

TREATMENT OF LONG-STANDING CASES.—Cases of ununited fracture of the patella sometimes come under observation long after the injury, because the patient desires to have something done to remove his disability. The complaint generally is that the separation between the fragments is so excessive that there is no proper control over the limb, and that, while walking upon the level is possible, there is little power when walking up or down hill or up and down stairs. This may be due to a thin elongated fibrous union between the fragments, to adhesions of the patella to the femur, or to adhesions within the capsule of the joint and rigidity of the articular tissues generally. There is generally considerable muscular atrophy and weakness in addition. In these cases surgeons are agreed that operation is advisable, but unfortunately the results are not nearly so satisfactory as they are in recent cases, and much time and trouble are required to obtain even a fairly satisfactory result.

Secondary Suture of the Patella.—An incision is made similar to the one recommended for recent cases (see p. 398), except that the convexity of the flap should extend farther up the thigh, so as to expose the lower part of the belly of the quadriceps. After the flap has been turned down, the fibrous union between the fragments is removed, and the fractured surfaces are refreshed by means of a saw, chisel, or bone forceps. Great care should be taken to see that the direction of the two raw bone surfaces corresponds; accurate coaptation is essential to success.

Any adhesions must now be got rid of. When the patella is bound down to the femur, it may be freed by means of a knife. Any adhesions in the supra-patellar pouch, which prevent the upper fragment from coming down, should be divided with a probe-pointed knife passed into the pouch; the knee should then be bent forcibly, so as to break down any adhesions remaining. It is important to remember that the adhesions should not be broken down until the fibrous tissue connecting the two

fragments has been removed. We have seen cases in which violent flexion was employed before the fibrous tissue had been taken away; the result was that the upper fragment of the patella was broken up, owing to the soft atrophied bone being so firmly attached to the femur that it was unable to withstand the pull of the firm fibrous union upon it.

The limb is now fully extended, and an attempt is made to bring the upper fragment down into contact with the lower. It is necessary that the fragments should be closely approximated without tension, as otherwise the wire readily cuts its way through the bone, which is often very soft in these old-standing cases. If the upper fragment cannot be drawn down properly, the quadriceps should be divided above its junction with the tendon. If the tendon itself be divided, it is apt to unite badly; its division might also interfere with the blood-supply of the bone. If, however, the muscle be divided, union will occur readily, and no interference with the blood-supply need be feared.

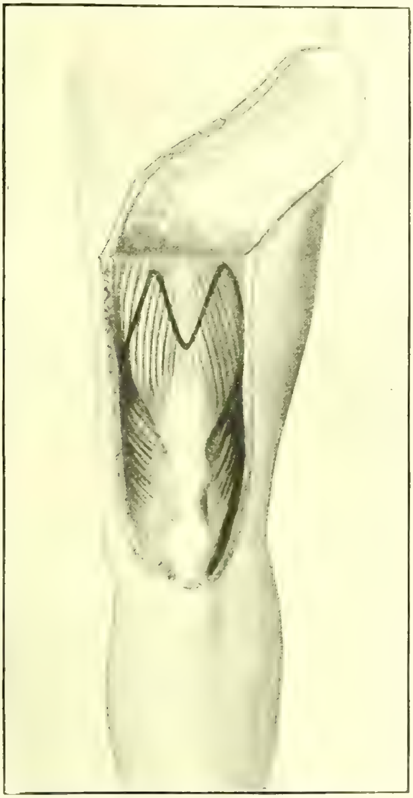


FIG. 203.—METHOD OF LENGTHENING THE QUADRICEPS EXTENSOR CRURIS. This is a preliminary to secondary suture of a fracture of the patella.

Lengthening the Quadriceps Extensor.—The quadriceps should be freely exposed; if this has not been properly done by the original incision, a median vertical incision should be made from the top of the convex one up the front of the thigh and the two flaps turned aside. A series of V-shaped incisions are then made through the muscle in an exactly similar manner to that already described for lengthening the triceps in old fractures of the olecranon; two V's, each limb of which is about two inches in length, are sufficient (see Fig. 203). With an incision made in this manner there is no fear of non-union of the muscle. If this does not allow the patella to come down sufficiently, it will probably be on account of adhesions remaining in the supra-patellar pouch, which may be divided by introducing the knife on the flat into the pouch and cutting them. When the fragments have been brought into contact, they should be wired together in the manner described for recent fractures (see p. 399);

but, if possible, the wire should be entered further from the fractured edge than in a recent case. The approximation of the fragments will be facilitated by elevating the leg and thus relaxing the quadriceps ; in very bad cases it is only by so doing that the fragments can be brought together even after division of the muscle.

After-treatment.—The limb is placed in a well-padded Croft or Gooch's splint, and laid upon a high inclined plane for a few days ; after two or three days the elevation is diminished, and in about ten days the limb can be allowed to lie flat on the bed. At the end of a week, the stitches are removed, a collodion dressing is applied and the splint left off. It is inadvisable to begin passive movement as early as is done in recent fractures on account of the division of the muscle, which requires at least three weeks for proper union. In the meantime, however, the patient should keep up a certain amount of movement by gently moving the knee in bed, and massage should be employed; at the end of three weeks passive motion may be definitely begun. The result is generally fairly satisfactory ; the patient rarely gets movement beyond a right angle, even if he gets as much as that ; but still he is in a much better condition than he was before, with a firm limb and a fair range of movement.

Apparatus.—When no operation is permitted, all that can be done is to fix on a knee-cap, which keeps down the upper fragment, holds the knee stiff, and so gives the patient fair support.

COMMINUTED FRACTURE OF THE PATELLA.

When the fracture is due to direct violence, such as a blow upon the knee, the line of fracture is usually starred or comminuted, and there is not the same tendency to separation as in the ordinary transverse fracture due to muscular action. It is not uncommon to find the periosteum more or less intact, and the fragments are thus held together by it.

TREATMENT.—If the limb be put at rest on a splint for three or four weeks, and massage and careful passive motion employed for another three or four, bony union and good movement generally result. If, however, the fragments be separated, or do not lie at the same level, it is well to cut down on them and bring them together as for the transverse form of fracture. Thin wire should be used when the fragments are small, and especially when the fracture is a vertical one, as it will have to bear only a slight strain. A splint should be applied and kept on for about a fortnight ; the patient should be kept in bed for another two or three weeks, the limb being massaged in bed and gentle passive motion being practised.

COMPOUND FRACTURE OF THE PATELLA.

This is comparatively rare; it may, however, be the result of direct injury and is then generally starred.

TREATMENT.—This must be primarily the treatment of an injury

to the joint, and will consist in careful disinfection of the wound, removal of any loose fragments of bone, and sponging the fractured surfaces with pure carbolic acid, which must not be allowed to run into the joint. The latter is then washed out with sterilised saline solution. The fragments of the patella may be wired if necessary, and one drainage tube inserted into the joint and another between the bone and the skin.

After-treatment.—The case must be carefully watched lest sepsis should occur ; if it does, it will be necessary to make free incisions into the joint and irrigate it with saline solution until the violence of the inflammation has subsided. In some cases it may be necessary to excise the joint or amputate the limb. Further details on these points will be found under Wounds of Joints (see Vol. III.).

VERTICAL FRACTURE OF THE PATELLA.

This form of fracture is rare, and generally results from direct blows upon the bone. The separation of the fragments is only slight, and the fibrous structures over them are generally but little damaged.

TREATMENT.—What has already been said above with regard to Comminuted Fracture of the Patella applies equally to this form.

CHAPTER XXI.

FRACTURES OF THE LEG AND FOOT.

In the great majority of cases both the tibia and the fibula are broken; either bone, however, may be broken separately.

FRACTURES OF THE TIBIA ALONE.

The fractures may be grouped into those of the upper end, the shaft, and the lower end.

FRACTURES OF THE UPPER END OF THE TIBIA.

These injuries are rare. The fracture sometimes involves the articular end of the bone, as in falls from a height on to the feet, when the tibia is driven forcibly up against the condyles of the femur and the tuberosities of the tibia are split. This is sometimes spoken of as a 'compression fracture.' In some cases the spine of the tibia is detached, and in children a separation of the epiphysis is occasionally met with. Fracture may also occur just below the tubercle and is generally due to severe direct injury, such as the passage of a cart over the limb. The fracture may be transverse or oblique; when it is transverse there is usually slight displacement owing to the breadth of the fractured surfaces. When it is oblique, the obliquity is generally from above downwards and forwards, and the upper fragment projects somewhat anteriorly.

TREATMENT.—In a case of **compression fracture**, an anæsthetic should be administered, firm extension exerted, and the fragments manipulated into position. *Extension* will be required to prevent the tibia from being pressed up against the femur. Ordinary weight extension (see p. 275) with four to six pounds will generally suffice. Any tendency to outward rotation of the leg is best counteracted by applying a back splint as high as the knee and making extension from the splint. Evaporating lotions (see Vol. I. p. 9) will be required for the first ten days to subdue the effusion in and around the joint.

At the end of a fortnight, *massage and passive movement* should be begun, and a week later a *Croft's splint* may be applied, while the massage and passive movement are continued daily. The fracture is followed by effusion of blood into the joint, and hence massage and passive movement are very important if a movable joint is to be obtained.

When the **spine of the tibia** is broken off, the diagnosis is usually only made after the joint has been opened on account of symptoms resembling a loose body in the joint, or a so-called internal derangement. The detached spine of the tibia should either be pegged into place or removed entirely if the fractured portion be small. Stereoscopic radiography should always be employed when there is any suspicion that the case is of this nature.

Fig. 204.—Oblique Fracture of the Tibia.

In **transverse fracture** just below the tubercle, or **separation of the epiphysis,** it is only necessary, after having manipulated the fractured ends into position under an anæsthetic, to apply a *Croft's splint* (see p. 266), which is opened on the following day and can be transformed afterwards into a permanent casing. The splint should extend from the middle of the thigh to the ankle. When the fracture is oblique there is a tendency for the upper fragment to protrude forwards. This may be overcome by placing the limb in the fully-extended position, and then applying a Croft's splint from the foot to the middle of the thigh; if not, it may be necessary to expose the fractured ends and fasten them together (see p. 305).

FRACTURES OF THE SHAFT OF THE TIBIA.

These are much more common than fractures of the upper end, and usually occur in the lower third. The cause is generally direct violence, such as a run-over injury, but it may also be due to indirect violence. When due to direct violence, the fracture is often comminuted and not infrequently compound, but is generally transverse in direction; when it is due to indirect violence there is often considerable obliquity of the

line of fracture from below upwards and backwards. In a fracture from direct violence there is only slight displacement, unless the fracture be comminuted; the upper fragment is tilted somewhat forwards while the lower is carried backwards by the weight of the foot. There is usually a good deal of bruising of the skin, which is apt to slough if any pressure be put upon it. This point must be remembered in putting up the fracture.

TREATMENT OF A SIMPLE FRACTURE.—When the lower fragment is brought into line with the upper, means must be taken to relax the calf muscles—especially if the fracture be oblique—as their contraction pulls the lower fragment up behind the other, while at the same time the quadriceps extensor cruris is apt to produce a tilting

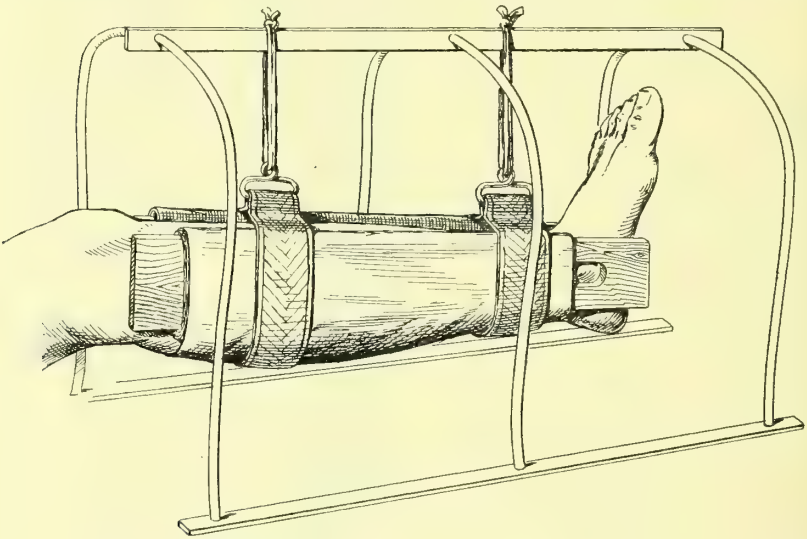


FIG. 205.—'FRACTURE BOX' OR 'BOX SPLINT' FOR FRACTURES OF THE LEG. The two lateral splints are rolled up in a folded sheet, fastened to the limb by straps and buckles, and the whole apparatus slung to the cradle. A bandage is usually also put on over all.

forward of the lower end of the upper fragment, the result being that union occurs with the fragments in bad position and the sharp lower end of the upper fragment may perforate the skin. There is not so much danger of this accident happening as there is when both bones of the leg are broken, as the unbroken fibula acts as a splint.

After reduction of the fracture is complete, the limb may be put up in a MacIntyre's splint, with the heel supported (see p. 414); a pad is placed over the tibia a little above the fracture, and bound down so as to keep the upper fragment in position. This pad must not be applied too near to the fracture, as otherwise the skin will be likely to slough from the pressure. If there be any difficulty in bringing or retaining the fragments in proper position, it is well to cut down on the fracture and

fasten the fragments together (see p. 305). At the end of a fortnight the leg may be put up in a Croft's splint, and a perfect result should be obtained. Hessing's splint (see p. 375) may also be used at this time and enables the patient to get about.

If the effusion be so great as to threaten the vitality of the skin, the limb may be fixed either in well-padded lateral poroplastic splints, not bandaged on too firmly, or, still better, in what is termed a ' box splint.' This *box splint*, or ' fracture box,' is also a very convenient form of apparatus for fractures of both bones of the leg, and is constructed as follows : Two pieces of wood as broad as the antero-posterior diameter of the leg, and long enough to extend from the tuberosity of the tibia to three inches beyond the sole, are rolled up in opposite ends of a sheet as broad as the splints are long, until they almost meet in the middle. The leg is then placed upon the sheet in the interval thus left, and the splints are turned up on each side, all hollows between the limb and the splints being filled with wool pads. The sheet between the two splints supports the back of the leg and the heel, and an extra pad should be placed just above the latter. The splints are fastened on with webbing straps and buckles, and a bandage is applied outside them ; the whole apparatus is then slung in a cradle, the knee being bent nearly to a right angle (see Fig. 205). No pressure is exerted upon the damaged skin by this splint, and by unbuckling the straps the seat of fracture can be exposed without disturbance.

Blisters containing blood-stained fluid are often present in these cases ; if they occur, the skin should be disinfected (see Vol. I. p. 100), the blisters punctured, and boric ointment applied over them. The blisters will heal and the swelling will subside in a few days, unless gangrene is going to occur ; after they have healed, the limb may be put into a Croft's splint. The box splint might be used throughout, but the Croft is certainly more convenient as soon as there is no longer any risk of pressure. The splint should be kept on for about six weeks.

TREATMENT OF A COMMINUTED FRACTURE.—A comminuted fracture, is often accompanied by injury to, and subsequent sloughing of, the skin. The treatment is similar in all respects to that just described. Should it be evident that the skin will slough, the neighbourhood of the fracture must be rigidly cleansed ; cyanide gauze dressings should be applied daily. Should the skin recover, a Croft's splint may be applied after a week or ten days ; should the skin slough, the treatment will be that for gangrene due to crushing (see Vol. I. p. 69). Union will usually occur in about six weeks ; special care should be taken to see that it is quite firm before the patient is allowed to get about, except in the cases in which Hessing's splint (see p. 375) is employed ; in this the patient can walk freely.

As these fractures are at some distance from the joints, there is no very great risk of stiffness either at the ankle or the knee ; but it is well

to keep the foot at right angles to the leg, so that, should stiffness occur, the patient can put the sole of the foot flat on the ground; this is also the best position from which to commence passive movement afterwards.

TREATMENT OF A COMPOUND FRACTURE.—A wound is very commonly present in the fractures due to direct injury; it may not communicate with the fracture, but it often does. The treatment of compound fractures in general has already been described (see p. 283); the difficult point in the management of the cases under consideration is how to provide for the due immobilisation of the fracture, and at the same time to take proper care of the wound. If the fracture be comminuted, any detached fragments should be removed; those that retain any connection with the tissues around should be left, after being manipulated into position. Then the fragments are got into position and secured as firmly as possible by means of two or more bone-plates (see

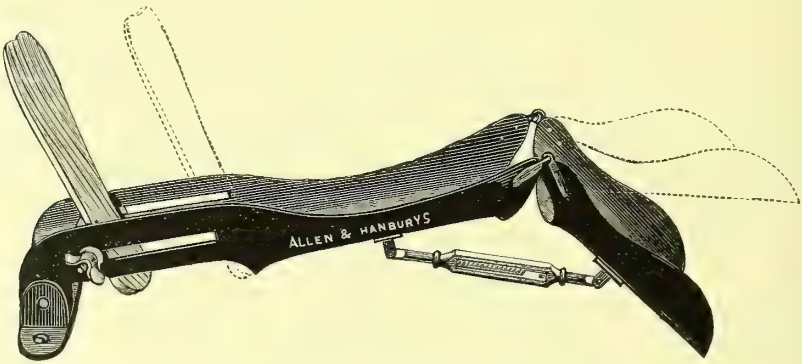


FIG. 206.—MACTINTYRE'S SPLINT. Both the foot-piece and the thigh-piece are adjustable.

p. 307). Any incision made by the surgeon for the examination of the wound should be stitched up, unless required for drainage, while the original wound is left open. It is useless to attempt to bring the contused edges together, because they will not unite by first intention, and besides it is necessary to provide for drainage, should sepsis occur.

The limb should be put up in a MacIntyre's splint with the knee bent nearly to a right angle. The splint is provided with a foot-piece which can be inclined at an angle. The heel must be supported by passing a broad bandage across, opposite the heel, through the slots in which the foot-piece moves, and tying it behind the splint. By this means the heel can be raised or lowered to the requisite degree. The splint is padded with a folded sheet, over which is placed a piece of sterile jaconet or mackintosh, so as to prevent the sheet being soaked by discharges from the wound. Upon the splint thus prepared is placed, first, a thick layer of salicylic wool, and then pieces of cyanide gauze reaching from the ankle to the knee. These should be arranged like a many-tailed bandage, so

that when the leg is in position upon the gauze, the ends can be folded over in front. When this has been done, salicylic wool is applied over the dressing in front, and the leg firmly bandaged to the splint. In arranging the padding the leg must be kept carefully in position and there must be no pressure on any bony point. The usual rule for ascertaining whether the limb is in proper position is to see that the inner condyle of the femur, the ball of the great toe and the internal malleolus are all in the same plane. The best plan, however, is to expose the other leg and to compare the two sides. If the fragments have been fastened together, the fixation apparatus ensures their being in proper position.

After-treatment.—At first the dressing must be changed every day. This may be done with the least possible disturbance by having a second MacIntyre's splint at hand, arranged similarly to the first. The original dressing is then turned aside without disturbing the leg, the wounds are washed, and an assistant supports the thigh, while the surgeon gently lifts the leg, grasping it firmly at the ankle and above the fracture. The splint and dressing are then taken away, an assistant washes the back of the leg, the fresh splint is placed in position, the leg laid down on it, and the dressing arranged as before. It is only during the first ten days that frequent dressings are necessary ; after that, it will suffice to turn aside the dressing, pack in a little gauze along the side of the leg, and then apply a fresh piece of dressing in front, so that for several days the back of the leg need not be disturbed, and no change of splint is necessary. As soon as healing has occurred, the leg may be placed in a Croft's splint and treated as a simple fracture. As only the tibia is fractured and the fibula remains intact, there is not much danger of unduly disturbing the fracture when the limb is transferred from one splint to another. Should it be impossible, however, to carry this out without risk, the interrupted plaster splint (see Fig. 127) should be employed instead.

TREATMENT OF UNUNITED FRACTURE.—Ununited fracture is chiefly due to imperfect fixation of the foot, and if prolonged rest in a plaster of Paris casing fails to secure union, operation becomes necessary. Bier's bandage may also be employed ; it should be kept on for two periods of two hours every day (see Vol. I. p. 13).

When the fracture is transverse, it may suffice to remove the fibrous tissue between the ends of the bone and to refresh the latter ; union will occur even though there be an interval between the fragments, provided that no soft parts are interposed. In one case of non-union in which the interval between the fragments, after removal of the intervening fibrous tissue, was not more than a quarter of an inch, we chiselled off a thin shaving of the tibia above the seat of fracture and hammered it firmly between the two fragments ; perfect union resulted. If the interval be considerable, however, the fibula must also be exposed and enough of it removed to allow the two ends of the tibia to come together. The tibia is then united by means of bone-plates (see p. 307). The former

method is always preferable if it can be adopted; if the fibula be resected, there may be delay in the union on account of the greater mobility of the limb.

FRACTURE OF THE LOWER END OF THE TIBIA.

Fracture in this region is extremely rare. Sometimes the internal malleolus is broken off by direct violence, such as a kick, without fracture of the shaft. There will be no displacement of the foot, and but little of the malleolus.

TREATMENT.—It suffices to put the leg up in a Croft's splint for about a fortnight. Passive movement and massage should be practised daily from the first. Union usually takes place readily.

FRACTURES OF THE FIBULA ALONE.

FRACTURE OF THE SHAFT.

The shaft of the fibula is rarely fractured alone, on account of its deep situation; the displacement is usually slight, as the tibia forms an excellent splint.

A Croft's splint should be applied for about a fortnight, with daily massage and passive movement of the ankle. After a fortnight the splint may be left off entirely, the massage and passive movement being continued; the patient may be allowed to walk in four or five weeks' time. It is essential to see that there is no mal-position of the foot.

POTT'S FRACTURE.

This is a fracture of the lower end of the fibula, accompanied by an outward and backward displacement of the foot. The fracture of the fibula is frequently associated with fracture of the internal malleolus. Sometimes, however, the internal lateral ligament of the ankle gives way, and the malleolus either remains intact or a mere shell of bone is torn from it. The fibula is fractured from an inch to an inch and a half above the base of the malleolus. The typical Pott's fracture is always due to indirect violence; fracture may occur in this situation from direct injuries such as kicks, but it is then unaccompanied by the displacement of the foot, and cannot therefore be looked upon as a Pott's fracture. In most cases of Pott's fracture, there is displacement backwards as well as outwards; in cases which result from catching the heel, the backward displacement is very marked and has to be specially counteracted. As the fibula breaks, the internal malleolus usually gives way, and there is more or less tearing of the anterior and posterior tibio-fibular ligaments. The fracture is usually somewhat oblique and there is some angular displacement. This injury is of great importance, because

marked disability will result unless the displacement of the foot be remedied entirely. When the fracture has been allowed to go untreated, the patient is hardly able to walk at all, and the condition known as 'traumatic valgus' occurs.

Complications.—The injury always involves the joint, and, therefore, there may be great difficulty in preserving free movement of the ankle. Defective movement may be due to imperfect reduction of the fracture, to union of the fractured surfaces in bad position, or to adhesions in the joint. Imperfect reduction may result either from inability to restore the internal malleolus to its proper position, or, more rarely, from the interposition of tendon, fascia or ligament between the articular surfaces of the tibia and the astragalus. The tendon most likely to give trouble is that of the flexor longus hallucis. These fractures are prone to become compound; indeed they are not uncommonly compound from the first, the lower end of the tibia piercing the skin over the base of the malleolus and protruding on the inner side. Even when the fracture is not compound at first, it may become so secondarily, either from laceration of the skin before reduction, or from gangrene or ulceration afterwards. Persistent œdema of the leg and stiffness in the ankle-joint from adhesions in the tendon sheaths are also frequent complications.

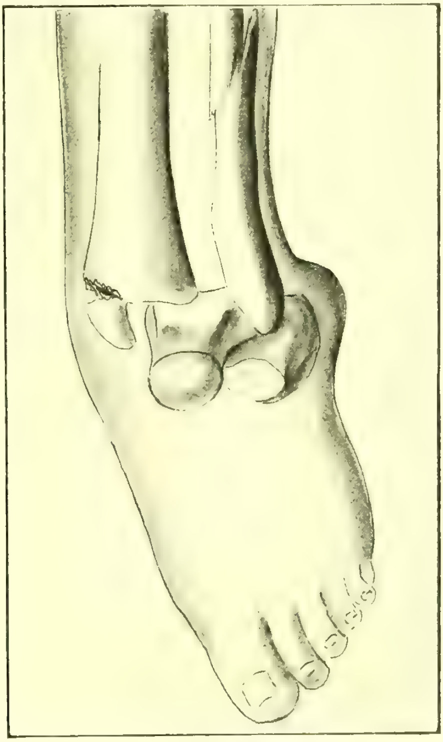


FIG. 207.—POTT'S FRACTURE.

TREATMENT OF SIMPLE FRACTURE.—The first point is *accurate reduction* of the deformity; and the second, careful fixation of the part so that dislocation shall not recur. As a rule it is best to administer an anæsthetic; no doubt reduction can be effected without it, but the pain and the contraction of the muscles render it difficult, and the difficulty is increased when there is also backward displacement of the foot, as the calf muscles tend to prevent the heel coming properly forward. When the muscles are fully relaxed, the knee is flexed and the upper part of the leg is fixed by an assistant, while the surgeon grasps the foot with one hand and the leg with the other and manipulates the foot into position.

After reduction has been effected, the foot should be well inverted, so that the internal malleolus falls into its proper position and the deformity in the fibula is obliterated. It is important to be sure that there is no obstruction to the movements of the ankle, that the internal malleolus is not caught between the astragalus and the lower end of the tibia, and that

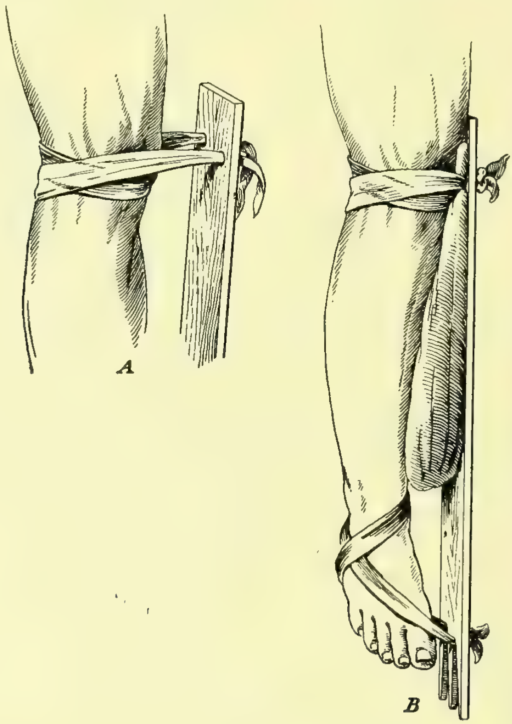


FIG. 208.—DUPUYTREN'S SPLINT. The function of this splint is to overcome the outward displacement of the foot. In *A* is shown the manner in which the upper end of the splint is fastened to the leg so that it cannot slip. A folded handkerchief is applied around the limb on a level with the tubercle of the tibia. In *B* is seen the method of inverting the foot. The splint may be further secured to the leg by a bandage.

there is no tendon or fascia interposed between the articular surfaces. This is readily ascertained when reduction has been effected. When the surgeon is satisfied that the joint is in good position, and that nothing interferes with its movements, the limb should be fixed, with the foot firmly inverted.

Splints.—If there be no marked swelling or difficulty in reduction, the simplest plan is to put on a *Croft's splint* (see p. 266), extending from above the knee to the ball of the toes; if there be much spasm of the muscles, it is well to make the splint extend up only to the tubercle of the

tibia and then to flex the knee, and swing the leg from a cradle or place it upon an inclined plane. The foot is held in position until the splint dries, and the greatest care is taken to keep it at right angles and fully inverted. This is one of the strongest reasons for using an anæsthetic when reducing the fracture, as it is then easy to ensure that the foot remains in good position until the splint is firm. In this particular fracture it is essential to adopt treatment to obviate the possibility of stiffness of the ankle, and the method already described on p. 280 of treating fractures largely by massage finds its most useful application here. Owing to the readiness with which displacement recurs, however, the greatest care has to be taken to fix the fracture while the joint is moved ;

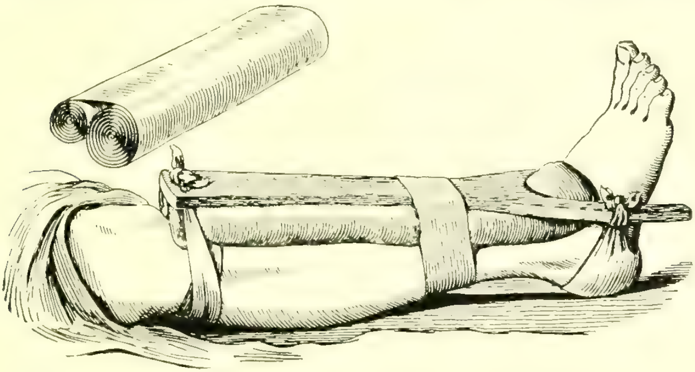


FIG. 209.—SYME'S HORSE-SHOE SPLINT. The object of this splint is to rectify the backward displacement of the foot. The sling embracing the heel may be made of elastic webbing. The smaller figure shows the method of rolling up lint to make the padding. The splint is commonly supplied with two holes bored in its upper end. It is then secured to the upper part of the leg in a manner similar to that shown in Fig. 208, *A*. It is a difficult splint to use with success, as it needs great care to prevent the occurrence of a pressure sore over the instep where the edge of the horseshoe cuts into the extensor tendons. Such an accident is one of great gravity owing to subsequent adhesions.

even after some time displacement may still occur from want of attention to this point, or from mere looseness of the splint due to shrinking of the limb or alteration of the padding.

After-treatment.—The splint can usually be left off in about three weeks, but the patient should not be allowed to bear weight on the foot for seven or eight weeks, lest the weight of the body should produce a valgus condition. So long as massage and passive movement are thoroughly practised, there is no fear of stiffness in the joints, and there is therefore no need to bear weight on the foot too early when this treatment is adopted. The patient may get about on crutches, with the knee flexed and the leg suspended by a bandage round the neck or supported in a knee-rest.

Operation.—Should it be impossible to reduce the fracture properly, or should the deformity recur in spite of the treatment advised above, it will be advisable to expose the seat of fracture without further

delay, get the fractured surfaces into accurate apposition and fasten the fragments by means of bone-plates (see p. 307) or tacks. The limb may be put up in wire-netting splints (see p. 265) and early passive movement should be resorted to.

If for any reason the surgeon should decide not to operate on a fracture of this type, the displacement of the foot may sometimes be satisfactorily overcome by the use of such splints as Dupuytren's (see Fig. 208) or Syme's (see Fig. 209). Neither of these should be used, however, in preference to operation, but only as a substitute for it. The method of applying the splints is given in the description of them.

TREATMENT OF COMPOUND FRACTURE.—A compound Pott's fracture is a very serious condition, as it is a compound fracture communicating with a joint. Fortunately the wound generally results from the end of the tibia being driven through the skin, so that there is no primary infection of the joint ; any dirt or foreign matter present is generally in contact with the end of the bone and does not often find its way into the joint, so long as the surgeon takes cares not to replace the protruding bone until thorough disinfection has been carried out. Cases of compound fracture of this kind, seen before the materials for proper disinfection are at hand, should be put on a splint without any attempt to reduce the fracture until the necessary arrangements can be made. Great care should be taken to prevent premature reduction.

The further treatment is that already described for compound fracture (see p. 283) ; the end of the bone is most carefully disinfected, the whole of the malleolus being protruded and the skin wound enlarged if necessary ; the skin is also disinfected and the joint is washed out. Advantage should be taken of the free exposure of the parts to fasten any considerable portion of the internal malleolus that may have become detached in position by tin-tacks or a bone-plate (see p. 307). A drainage tube is inserted at the back of the joint, the fracture reduced, and the leg and foot put up in sterilised lateral wire splints (see Fig. 113), incorporated with the dressing and keeping the foot at right angles to the leg, and fully inverted. The advantages of these wire splints have been pointed out on p. 265. When the wound has healed, treatment similar to that of a case of simple fracture—viz. a Croft's splint, massage, and passive movement—may be reverted to.

TREATMENT OF MAL-UNION.—Cases are sometimes met with in which reduction has been imperfect or has not been attempted, and the result is the condition commonly called 'traumatic valgus'; in this painful and crippling condition the patient limps considerably, and often has agonising pain on attempting to walk. It may be necessary to have recourse to surgical intervention to render walking possible. Two procedures suggest themselves for this purpose, one being to divide both bones of the leg and then to invert the foot forcibly, whilst the other consists in reproducing the original injury and then bringing the parts into proper

position. Successes following the former method of treatment have been recorded, but, as a rule, the results are not satisfactory, since the astragalus is not in its normal position with regard to the articular surface of the tibia and fibula and the ankle remains as stiff as ever.

We have had good results from the second method. The fracture should be freely exposed by a vertical incision over it in front, and the union divided somewhat obliquely downwards and inwards. A longitudinal incision should also be made over the inner border of the tibia, carried forwards on to the foot, and deepened until the lower end of the tibia is completely exposed. If it be found that the broken internal malleolus has become fused to the articular surface of the tibia by a mass of callus, so that there is no possibility of bringing the astragalus into its proper position, the remains of the internal malleolus should be removed, and the proper curve of the articular surface reproduced by means of a gouge. The articular cartilage will probably be found intact over the lower end of the tibia external to the base of the malleolus, and also over the greater part of the astragalus.

Powerful extension should now be made and the lower end of the tibia pushed outwards, while an assistant exerts pressure on the outer border of the sole so as to drive the foot forcibly inwards. It may be necessary to remove some soft tissues between the tibia and fibula before the foot can be got inwards far enough, but after a little trouble the parts can probably be loosened completely, and the deformity made to disappear entirely, the astragalus passing into its proper position in relation to the lower end of the tibia. If possible a flap of soft tissues, as recommended by Murphy, should be turned in between the astragalus and any portion of the tibial articular surface that has been made raw.

The wounds should be stitched up, and dressings applied, in which are incorporated wire splints to keep the foot inverted and to prevent the heel from being pulled backwards. Passive movement should be begun early with a view of preventing adhesion between the articular surfaces. The results are often satisfactory ; a considerable range of movement may be obtained, while the pain, of which the patient complains, disappears entirely.

FRACTURE OF THE LOWER END WITHOUT DISLOCATION.

The displacement typical of Pott's fracture does not always occur in connection with fractures of the fibula above the malleolus. Thus the injury may force the foot inwards instead of outwards, the result being that the strain is thrown on the external lateral ligament, which is usually strong enough to stand the strain, while the fibula gives way at its weakest part, namely, just above the malleolus. There is little or no displacement of the foot in this form, and, therefore, the condition is not the ordinary Pott's fracture.

TREATMENT.—The simplest and most efficacious method is to apply a Croft's splint when the case is first seen. The later treatment will be on the lines already laid down for Pott's fracture (see p. 419).

DUPUYTREN'S FRACTURE.

A much rarer fracture than Pott's is that known as Dupuytren's, which generally occurs when the patient falls from a height and alights flat upon the sole; the astragalus is driven upwards between the tibia and the fibula, the inferior tibio-fibular ligaments are torn, and the fibula is fractured near the lower end of the shaft, usually a little higher up than in Pott's fracture. This fracture is generally produced by very severe violence, and it may be accompanied by fracture of the astragalus, os calcis, or the inferior articular surface of the tibia. The diagnosis is facilitated by the marked broadening of the ankle that is always present; there is not as much eversion as in ordinary Pott's fracture. A radiogram will generally be required to clear up any doubts that may exist.

TREATMENT.—This is often very difficult. The astragalus is driven up between the bones of the leg and extension is required to bring it down. The patient should be put under an anæsthetic and the leg fixed by an assistant with the knee bent almost at right angles, while the surgeon makes firm extension on the foot and at the same time presses together the malleoli and inverts the foot. The main point in the treatment is that the fracture should be reduced satisfactorily as soon as its nature is recognised. As a rule displacement does not recur if the foot be kept firmly inverted so that the upward pressure of the astragalus tells against the articular surface of the lower end of the tibia, and not against the tibio-fibular articulation.

After the fracture has been reduced, the leg should be fixed in a Croft's splint. The subsequent treatment is the same as after a Pott's fracture (see p. 419).

TREATMENT OF MAL-UNION.—When the deformity is of long standing and cannot be remedied by manipulation, operation will be necessary. The incisions are similar to, but longer than those for the treatment of Pott's fracture (see p. 421); and the operation, which is extremely difficult, aims chiefly at restoring the astragalus to its place beneath the tibia. All the soft parts, especially the tendons, must be restored to their natural position, and any loose fragments of bone or newly-formed fibrous tissue should be excised. The fibula will usually require division at the seat of fracture, and it is well afterwards to fix the two portions of it together with a bone-plate (see p. 307). The remaining steps and the after-treatment are identical with those of the operation upon cases of mal-united Pott's fracture (see p. 421).

FRACTURES OF BOTH BONES OF THE LEG.

These are among the commonest fractures in the body and, apart from the difficulties which not infrequently arise in their treatment, they are important because a considerable number are compound—according to some authors, as many as one in three or four. They may occur from direct violence, such as run-over injuries or kicks, in which case the tibia is not infrequently comminuted, the line of fracture more or less transverse, and the fracture compound. More often, however, they result from indirect violence, when the fracture in the tibia takes place at the weakest part—a short distance above the malleolus—whilst the fracture in the fibula generally occurs higher up, often near its upper end. The line of fracture is generally oblique from below upwards and backwards in both bones. When these fractures are compound it is generally due to perforation of the skin by the sharp upper fragment of the tibia. Spiral, T-shaped, and longitudinal fractures of the tibia are met with, but the spiral and the oblique fractures are the two common forms.

In a fracture from direct violence there is not necessarily any displacement at first ; when the leg is lifted, however, the weight of the foot, of course, carries the lower fragment backwards. In an oblique fracture from indirect violence the lower fragment is pulled upwards and somewhat backwards, so that the upper fragment of the tibia projects beneath the skin and is apt to perforate it either at the time of the accident or subsequently, unless the limb be fixed in proper position. There is a tendency also for the lower fragment to rotate outwards owing to the weight of the foot, especially when the fracture is high up the bone.

TREATMENT OF A SIMPLE FRACTURE.—In treating a simple fracture of the tibia and fibula in this region, the surgeon has to bear in mind the liability that there is for the fracture to become compound, and the tendency to shortening and outward rotation of the foot.

In a *simple fracture due to direct violence*, the bones should be brought into accurate position ; the two fragments should be in the same straight line, and there should be no rotation of the foot and the lower fragment. It is well to take a radiogram in the course of a few days, before the parts become consolidated, so as to see if the fractured ends are in good position. If there be much bruising of the skin it is well to disinfect it and to apply an antiseptic dressing, lest ulceration or gangrene should take place. Then the limb may be put up in a Croft's splint, which should extend from the lower third of the thigh to the root of the toes ; care must be taken to see that the foot is at right angles to the leg.

In *oblique fractures* of the leg also the application of a Croft's splint before swelling occurs is the best procedure. Even if marked swelling has taken place, fixation of the part in this way will often prevent further swelling and aid the absorption of any that has already taken place. The toes must be closely watched, and the sensations of the patient as regards

pain ascertained ; if there be any sign of undue pressure upon the seat of fracture the splint should be undone at once.

The Croft's splint should be kept on for at least six weeks, but after three or four weeks' confinement to bed the patient may be allowed to get about on crutches, still wearing the plaster of Paris casing, the limb being supported by means of a long sling passing around the neck and beneath the sole. The splint may be left off any time between six and eight weeks, if firm union has occurred. If the fracture be low down, it is sometimes difficult to be sure whether the union is firm, as, when attempts are made to move the fragments in the antero-posterior direction, the movement of the ankle-joint may stimulate movement at the fracture; the best direction in which to test the movement is the lateral one. The matter is of great importance, because, if the union be imperfect when the patient bears weight upon the limb, the result will be to increase the mobility.

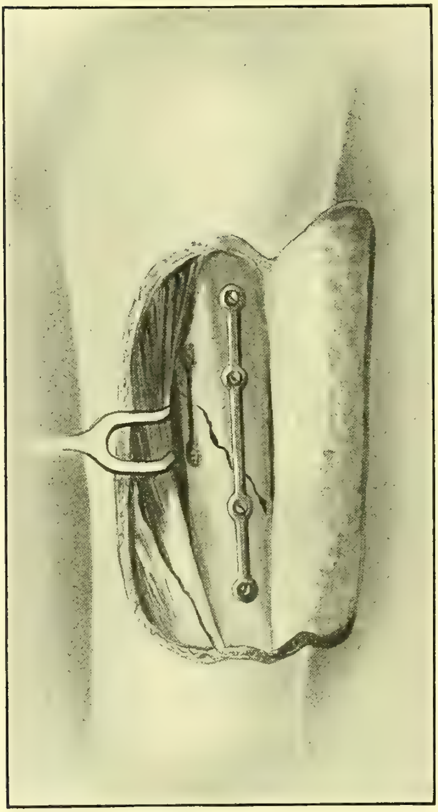


FIG. 210.—BONE-PLATES APPLIED TO AN OBLIQUE FRACTURE OF THE TIBIA. Two plates have been used, one long and one shorter. If possible the plates should not be applied over the subcutaneous surface as they will then be liable to become exposed to injury or irritation subsequently.

When there is much comminution, a MacIntyre's splint is very comfortable, but it has the great disadvantage that the leg cannot be satisfactorily radiographed in it, and hence it is impossible to tell how the fragments are lying. An excellent arrangement is Hessing's splint (see p. 374) by which extension can be kept up and the patient allowed to walk about almost from the first, without the foot touching the ground.

Operation.—In these fractures there is often considerable difficulty in keeping the fragments in proper position and in preventing over-riding. If it be ascertained by means of a radiogram or otherwise that there is recurrence of the over-riding after it has been once corrected, it is best to expose and fasten the fragments together. The fracture in the tibia is superficial, no important structures are divided in exposing it, and the

result is superior to that obtained by splints, whilst the after-treatment gives no trouble. The best incision is a curved one over the inner surface of the bone with its convexity backwards, extending well beyond the inner border of the tibia. This flap should be turned forwards until the whole breadth of the inner surface of the tibia is displayed. When the seat of fracture has been exposed, all blood-clot, small fragments of bone or portions of soft tissues that may have got between the fractured ends should be removed. The broken ends are then united by means of plates (see Fig. 210). To facilitate the drilling of the bone, a special form of forceps has been devised which holds the fractured ends in accurate apposition, whilst the bone is being bored (see p. 306). The fracture of the fibula does not require fastening. The wound is then stitched up and wire splints are incorporated in the dressings (see p. 265), the foot being fixed at right angles and the knee being also enclosed in the splint.

The further treatment is the same as that after any operation for fracture. When the wound has healed, a Croft's or Hessing's splint may be applied, which must not be left off until union has occurred, usually in about three months. It will be necessary to allow a somewhat long period to elapse before the patient is permitted to bear weight on the foot, as union is rather slower in these cases than in fractures not operated upon. Massage should be employed after the first fortnight so as to avoid the œdema which is otherwise likely to occur when the patient is allowed to walk.

Apart from the question of the displacement of the fragments, it may be necessary to expose the fracture when the surgeon cannot satisfy himself that the bony surfaces are properly in contact. It is not uncommon for the upper end of the lower fragment to perforate the muscles, and thus a certain amount of muscular tissue is interposed between the ends of the bones, and proper union is prevented. In other cases the fracture may be comminuted, and a detached portion of bone may become so displaced between the fragments that they are prevented from coming into proper apposition. If, when reducing the fracture therefore, no proper crepitus be found (which would show that there is something interposed between the ends of the bone), or if it be impossible to reduce the fracture properly, there is sufficient reason for cutting down upon the fragments, removing the obstacle and fixing the fragments together.

When the injury has resulted from direct violence it is not usually necessary to operate, for the displacement is not so marked ; in this case operation will only be called for when the bone is comminuted and some detached portion prevents the fracture being properly set. In all these cases a stereoscopic radiogram is necessary.

TREATMENT OF A COMPOUND FRACTURE.—Compound fractures of both bones of the leg are very common ; they must be treated on the lines already laid down for compound fractures in general,

the wound if necessary being enlarged and the part thoroughly disinfected (see p. 283). If loose fragments be present between the ends of the bones they should be removed, and the fragments should be fastened together by means of suitable bone-plates (see p. 307); a drainage tube should be inserted. It is best to use strong sterilised wire splints incorporated with the dressing, as they get a better grasp of the limb than any other form; their advantages have been already referred to (see p. 265). Like all compound fractures treated aseptically these cases are much slower in uniting than simple fractures, and often a long time elapses before firm union is obtained. If the patient can afford a Hessing's splint (see p. 374) this will enable him to get about much earlier.

When the wound is at the back of the leg—which is, however, rarely

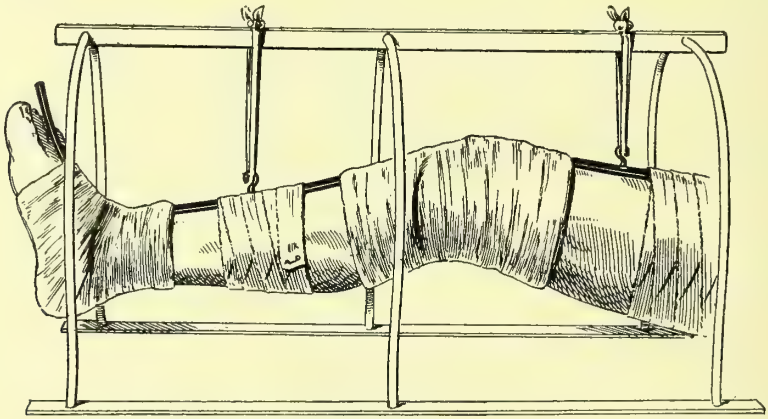


FIG. 211.—ANTERIOR SUSPENSION BAR FOR COMPOUND FRACTURE OF THE LEG. The limb is fixed firmly to the bar by plaster of Paris bandages about the knee and ankle. Between these points is seen the bandage securing the dressing.

the case—the limb is best immobilised by an anterior splint of malleable iron or two parallel splints, one running down on each side of the crest of the tibia reaching from the lower third of the thigh to the dorsum of the foot, and fastened by plaster of Paris bandages round the upper part of the leg and thigh on the one hand, and to the foot and lower part of the leg on the other. A sufficient interval is thus left for dressing the wound, and the splint may be slung in a cradle and the wound got at without disturbing the parts (see Fig. 211). As, however, there is likely to be some displacement of the ends of the bones, it may be necessary to fix the fracture mechanically first and then to sling the limb as above.

TREATMENT OF UNUNITED FRACTURE.—Ununited fracture of the tibia is fairly often met with; in the fibula the condition is rare. It is more common in fractures due to indirect violence than in those due to direct violence, and it is also common in compound fractures. The causes may be excessive movement, inclusion of portions of muscles, or,

not uncommonly, a loose piece of bone between the fractured ends, or apparently some constitutional defect.

In every case, the ununited fracture will have to be treated by operation, and the best plan is to cut down on the fracture. The other methods of treating ununited fracture which have been mentioned (see p. 304) are very unsatisfactory compared with free exposure; besides, there is no call to employ them in this situation, because the bone is quite superficial, and no important structures need be divided. The operation is in all respects similar to that described for ununited fracture of the tibia alone (see p. 415); a portion of the fibula should be removed if the ends of the tibia will not come together otherwise. For this purpose a separate incision must be made over the outer side of the leg or at some part where the fibula is easily accessible, but not necessarily at the same level as the defect in the tibia. Plates should be used to fix the fragments.

FRACTURES OF THE BONES OF THE FOOT.

These injuries are not common and may be dismissed in a very few words.

FRACTURE OF THE ASTRAGALUS.

Fracture of this bone alone is of extreme rarity. The fracture results from falls from a height upon the foot; the bone may then fracture or become dislocated. If it fractures, the anterior part of the bone is displaced forwards, the fracture being through its neck.

TREATMENT.—The treatment is difficult and will depend essentially on the condition of the astragalus, as shown by a radiogram; in most cases it would probably be advisable to expose the fractured bone, and in the majority of instances it would seem desirable to excise the astragalus completely (see Vol. I.). The movement of the ankle after removal of the astragalus is remarkably good, whereas if a piece of bone be left in the joint, a satisfactory result can hardly be expected.

FRACTURE OF THE OS CALCIS.

The most common fracture in the foot is fracture of the os calcis, which may occur from falls from a height upon the heel or from the foot being run over. The result is often comminution of the upper part of the os calcis; the posterior portion, to which the tendo Achillis is attached, may be broken off.

Many of these cases are overlooked and are treated as mere sprains. The mistake is of importance as these fractures are liable to leave much stiffness.

TREATMENT.—We shall refer to the treatment of extensive comminuted fracture, and of detachment of the posterior portion. When there

is an extensive *comminuted fracture* of the os calcis, the heel feels like a bag of bones and it is difficult to bring the parts into good position. The best plan is to divide the tendo Achillis, and then to hold the heel in position while the patient is under an anæsthetic and to put on a plaster of Paris casing so moulded as to bring the heel and the os calcis into proper shape; this is held whilst it sets, and the foot can then be slung with the knee bent. In these cases any resulting disability will be in connection with the transverse tarsal joint, not with the ankle-joint, and the apparatus should therefore be taken down from time to time for the performance of passive movement, especially in the transverse tarsal joint. Special care should be taken to prevent the occurrence of a valgus condition.

In *compound fracture* of the os calcis the treatment must follow the lines for the treatment of compound fracture, but if the bone be hopelessly broken up or if the chance of getting the wound aseptic be slight, it is as well to excise all the loose fragments; the parts that are covered by periosteum may be left and will help to form a new os calcis. The results of excision, under these conditions, are so satisfactory that it is not worth while running any serious risk in order to preserve a quantity of loose pieces of bone which are apt to become septic.

When there is *fracture of the posterior part* of the os calcis, and when the fragment is tilted or drawn upwards by the tendo Achillis, the best procedure is to turn down a flap with its convexity upwards and fasten the fragment of bone into position; the flap should reach high enough up the back of the ankle to escape friction from the hard part of the boot. Unless this operation be done, a projecting piece of bone will be left which will cause much pain when a boot is worn. It is also well to divide the tendo Achillis obliquely and to suture it so as to lengthen it (see p. 105).

Fractures of the other tarsal bones are comparatively rare except as a result of a general smash of the foot. As they are usually compound and associated with extensive injury, they do not call for individual description.

FRACTURES OF THE METATARSAL BONES.

These may be caused by run-over injuries or kicks, or heavy weights falling upon the foot. As a rule there is little displacement in these fractures, the other bones forming splints for the fractured one. All that is necessary is to see that the broken ends are brought into position by suitable manipulation, and then to fix the foot in plaster of Paris.

SECTION II.—DISEASES OF BONES.

CHAPTER XXII.

ACUTE AND CHRONIC INFLAMMATION OF BONES.

GROWING PAINS.

During the growing period, especially between the ages of thirteen and sixteen, young adults often complain of pains of varying intensity in bones and joints due to congestion of the medulla in the neighbourhood of the epiphyses, which are popularly termed 'growing pains.' There may be an elevation of temperature, and the condition is very likely to be confounded with commencing bone or joint trouble. On the other hand, these conditions may be mistaken for 'growing pains.'

The diagnosis is soon cleared up, however, because in this condition the pain passes off, and any stiffness of the joint disappears rapidly when the part is kept at rest. Although the pain may also disappear rapidly in true joint disease, the muscular rigidity and wasting persist. A radiogram may be of value in clearing up the exact nature of the trouble.

TREATMENT.—A cautious attitude is the safest and it is better at first to treat the case as if it were one of the graver affections of the bone or joint. The patient should be kept in bed, with the limb fixed on a splint. Fresh air, good food, warmth, quinine and alcohol in small quantities are all useful. If the case be one of simple congestion, the pain soon passes off, and no swelling will appear.

ACUTE INFLAMMATION.

Since a bone consists not only of dense osseous tissue, but also of periosteum and medulla, the inflammatory affections, by which it may be attacked may be divided into inflammation of the periosteum or

periostitis, inflammation of the bone itself or osteitis, and inflammation of the medulla or osteo-myelitis. When the periosteum is inflamed, the bone beneath is affected also, and when the medulla is inflamed, the bone and the periosteum are also attacked, so that all three forms are really present in most cases, the individual name given to the particular affection being determined by which of the three tissues is the principal seat of the disease.

Inflammation of bone may be *acute* or *chronic*; acute osteitis may be suppurative or non-suppurative. The chronic inflammations of bone are simple, tuberculous and syphilitic.

ACUTE NON-SUPPURATIVE OSTEITIS.

It is doubtful whether inflammation of bone, unaccompanied by suppuration and deserving the name 'acute,' does really occur; indeed, it is doubtful whether even a true acute periostitis can occur without a pyogenic infection. The acute periostitis described by Ollier as 'albuminous periostitis,' characterised by a serous or albuminous exudation beneath the periosteum, is probably only a mild form of the suppurative variety. Inflammation of the periosteum sometimes occurs during enteric fever, but this usually ends in suppuration, and is due either to the typhoid bacillus itself or to a pyogenic infection.

TREATMENT.—The treatment would clearly be the same as that appropriate for the early stages of the suppurative form (*vide infra*).

ACUTE SUPPURATIVE OSTEITIS.

This is usually spoken of as *acute osteo-myelitis*, because the inflammation usually begins in the medulla; the deeper layer of the periosteum, however, is the primary seat of the inflammation in a few cases.

CAUSES.—Acute suppurative osteo-myelitis occurs especially in young subjects, and may be followed by a general pyæmic infection. The disease may begin spontaneously or may follow an injury such as compound fracture. It is due to the pyogenic organisms, generally the staphylococcus pyogenes aureus, sometimes the albus, very rarely the streptococcus pyogenes.

In the *spontaneous form* these organisms are deposited from the blood, whence they may be derived from some preceding inflammatory condition, such as a boil. In other cases the disease may be preceded by digestive disturbance and diarrhœa, and here the organisms probably gain entrance from the intestinal tract. Often some local injury, such as a blow, a sprain, pressure, or exposure to cold, determines the localisation of the disease in a particular part. The spontaneous form is most common between the ages of ten and fourteen; it is very rare after twenty, and is more frequent in boys than in girls. The disease generally begins in the medulla in the neighbourhood of the

epiphyseal line; its commonest seats are the lower end of the femur, the upper end of the tibia and the humerus, and the lower end of the radius. It is rare for the disease to begin beneath the periosteum, most of the cases of suppurative periostitis being secondary to osteo-myelitis. Of the short bones the os calcis is, perhaps, most frequently affected. *The traumatic form* may occur at any age, and its situation is determined by that of the injury to which it is secondary.

PATHOLOGICAL CHANGES.—The affected area of the medulla becomes greatly congested and the effusion fills up the Haversian canals and the medullary spaces, and accumulates beneath the periosteum; the disease is therefore practically always a combination of acute periostitis and acute osteo-myelitis. The medulla becomes infiltrated, the periosteum thickened and swollen, and pus forms rapidly in both situations, sometimes after a communication has been established between the two, but often before a hole has been formed in the dense bone.

In young children the disease may remain localised to the neighbourhood of the epiphyseal cartilage, and is then termed *acute epiphysitis*; this condition may end in rapid destruction of the epiphyseal cartilage, or at any rate in solution of continuity between it and the shaft. More commonly, however, some portion of the latter also becomes involved.

When no surgical treatment has been adopted and the patient survives, necrosis of a portion of the bone always results; hence the term *acute necrosis* is often applied to this disease. The bone that dies is principally the dense shaft; the necrosis may involve the whole length of the diaphysis, or it may be limited to a small area in the vicinity of the epiphysis. It may also involve the entire circumference of the shaft, or only a part of the central or peripheral portion. The sequestrum generally consists mainly of the outer portion; at some part the whole thickness of the shaft may be involved, but seldom the whole circumference. The pus finds its way to the surface, and numerous sinuses may form later on, leading down to the sequestrum; these will persist as long as the dead bone remains.

When the abscess bursts, the severity of the inflammation usually subsides and separation of the dead bone commences. The length of time required for the separation of a sequestrum depends largely on the bone affected. In the case of the femur, the necrosed fragment may not be loose for six months or more, whereas in a smaller long bone, such as a phalanx, separation may take place within six weeks.

While the dead bone is being separated, the periosteum becomes thickened and new bone is formed from its deeper surface, so that by the time the dead fragment is loose, a layer of new bone will have formed around it, enclosing it in a cavity and only leaving a few apertures (termed 'cloacæ') through which the pus escapes. When the sequestrum is removed, it is often hard to realise that the dead portion originally

formed part of the outer surface of the bone, so deeply is it embedded in dense new bone (see Plate IV.).

The above remarks apply to acute suppurative inflammation of bone as it arises spontaneously; but the disease may occur in septic wounds where bones are divided, *e.g.*, amputations, compound fractures, etc. Under these circumstances the infection spreads up through the medullary cavity, and also frequently beneath the periosteum at the same time. The result is that, if the patient lives, there is usually necrosis of the whole of the lower end of the bone, which extends upwards for a considerable distance along the shaft; not infrequently other small independent sequestra are found at a higher level, especially in the central part of the bone.

SYMPTOMS.—These will depend on the virulence of the causal agents and the extent and situation of the disease. In any case there is usually violent fever and great pain; the fever soon becomes of the typhoid type, being accompanied by a small rapid pulse, headache, thirst, dry tongue, stupor or delirium, and the disease is often mistaken for typhoid fever. The pain is generally intense, and if the bone be superficial there is soon swelling over it; the skin becomes red or livid, and fluctuation occurs. On incision, pus escapes and the bone is found to be bare in parts, while in others the periosteum peels off readily. When the bone is deeply seated, or when the disease is confined to the medulla, the swelling and redness may not appear so early, but in any case the pain is extreme. In bad cases there may be complete separation of the epiphysis from the shaft, with very grave symptoms and rapid death. When the disease is in the neighbourhood of the epiphysis, the joint in the vicinity often becomes inflamed and swollen, though not necessarily infected and suppurating. If suppuration occurs in the joint, the prognosis is very bad.

RESULTS.—The course which the disease will take depends very much on the particular form of the affection and the treatment adopted. The patient may die before an abscess has time to form—sometimes as early as the second or third day—from septic intoxication or acute septicæmia; in other cases death occurs from pyæmia, septicæmia, ulcerative endocarditis or fatty embolism, or, at a later period, from exhaustion and waxy degeneration of internal organs, in connection with the continued suppuration consequent upon the necrosis. Early treatment may save even very bad cases. Under any circumstances, however, the prognosis is always grave, both as regards the immediate and the final result. The probability is that the patient will have a long illness, that there will be serious derangement of the neighbouring joints, and that, when the epiphysis is affected, deficiency in growth and deformity will result, the exact amount depending upon the extent of the disease and the age of the patient at the time of the attack.

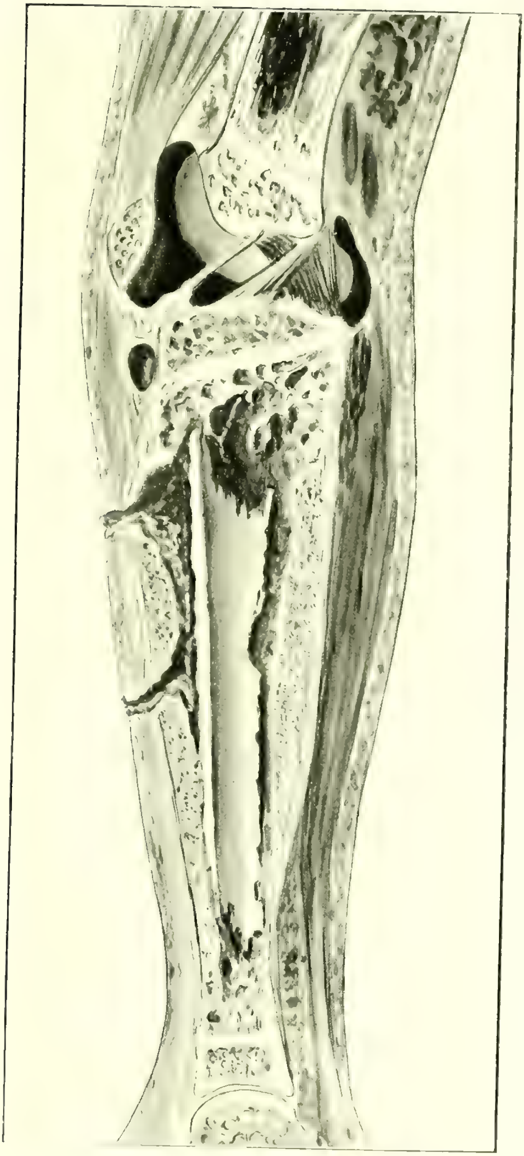


PLATE IV.

OSTEO-MYELITIS OF THE TIBIA.

The sequestrum, composed of the eroded diaphysis, lies in a cavity surrounded by new bone (the involucrum), from which discharging sinuses (cloacæ) open on to the skin, the margins of which are marked by prominent granulations. The knee-joint is distended with fluid.

TREATMENT.—We shall consider the treatment of acute suppurative inflammation of bone under the following heads: (1) acute suppurative periostitis, (2) acute suppurative osteo-myelitis, (3) acute epiphysitis, (4) those forms accompanied by suppuration in the neighbouring joints, (5) acute periostitis and osteo-myelitis following injury to bone and (6) acute suppurative osteitis of the flat bones. In all these forms, there is also the question of the removal of the dead portions or sequestra at a later period.

Of Acute Suppurative Periostitis.—Acute suppurative periostitis without any implication of the medulla undoubtedly does occur. The general symptoms are usually somewhat less severe than in acute osteomyelitis, and the swelling and the redness of the skin appear sooner.

Incision.—The affected part of the bone should be cut down upon as soon as the diagnosis is made, the periosteum divided, and the pus evacuated. When there is a considerable collection of pus beneath the periosteum three or four days after the commencement of symptoms, the case is probably one of primary periosteal inflammation, and the medulla need not be opened up at once; were this done in a case in which the medulla is healthy, the latter might become infected and a still more serious condition would arise. The whole of the bone from which the periosteum has been separated should be examined for a soft spot leading to the medulla and indicating a point of perforation from within. The incision should expose the whole of the affected area; a small incision is useless.

After-treatment.—The wound may be lightly stuffed with gauze to keep the skin edges apart, but it must not be packed so tightly as to interfere with the escape of the discharge. Large drainage tubes should be inserted down to the bottom of the wound among the packing unless the affected area of bone be quite superficial. If the operation be done with all antiseptic precautions, it is remarkable how little bone may die—sometimes none at all.

If, however, the constitutional symptoms are still severe after twenty-four hours, the presumption is that there is osteo-myelitis present as well, and, therefore, the stuffing should be removed, the edges of the wound held apart, and the medulla opened and treated as recommended below (see p. 434). If, on the contrary, the symptoms subside in two or three days, the stuffing may be removed and the wound stitched up again, except at the lower end, where a drainage tube should be retained until it is gradually pushed out by the granulations. If there be no necrosis, the wound will heal readily; if a sequestrum is going to form it will manifest itself partly by the persistence of a sinus and partly by the presence of bare bone which can be felt with a probe. But it must not be assumed that a sequestrum will necessarily separate in cases of acute periostitis because bare bone is felt for two or three weeks after the abscess has been opened. If the bone continues bare for six weeks

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or so, however, the probability is that a sequestrum will have to be removed later on.

Of Acute Osteo-myelitis.—Here the danger arises mainly from confinement of the pus under pressure within the medulla, and the patient's safety depends to a great extent on the pus finding an early exit.

Osteotomy.—Directly the diagnosis of acute osteo-myelitis is made, a free incision should be made down to the bone. By a free incision is meant not merely one through which the finger can be introduced, but an incision extending over the whole of the affected part of the bone. The periosteum should be incised, and the compact bone cut away so as to expose the medulla. This may be done by means of two or three large trephine holes afterwards joined together with a chisel and hammer, or the whole part may be laid open by a chisel or gouge and hammer. The medulla will be found very vascular and generally infiltrated with pus ; usually a drop or two of pus exudes as soon as it is opened. All soft inflamed and infiltrated tissue should be scraped away and the cavity sponged out with undiluted carbolic acid. Although a very free opening should be made into the medulla, it is not necessary to lay it open from top to bottom when a large extent of bone is involved ; it suffices to make two or three large openings, and through them to scrape out and disinfect the whole of the medullary cavity.

Although the patient's depressed condition renders it inadvisable to perform a more severe operation than is absolutely necessary, there must be no hesitation in getting free access to the medulla. In all probability the bone exposed by the first incision would die in any case, and it is possible that by cutting it away freely the whole portion which would have died may be actually removed, and so a proportionately rapid recovery may ensue.

After the medulla has been opened up and disinfected in this way, drainage tubes should be introduced into it, and gauze may be put in between the tubes to keep the skin edges apart. This gauze packing should not extend into the depth of the wound ; if the latter be stuffed tightly, as is sometimes done, the pus may be confined and its free escape from the medulla prevented. The object of putting in packing is to hinder the edges of the skin and the separated muscles from coming together, for that would prevent healing from the bottom. The limb must be put on a splint, the joints above and below the affected bone being fixed in the position in which they will be most useful afterwards.

After-treatment.—The wound must be kept open for a few days and afterwards drained thoroughly. Peroxide of hydrogen (10 vols.) may be used daily for irrigation. If a trough has been made in the bone, it is a good plan to stitch up the greater part of the wound as soon as the acute stage of the disease has passed off, or to deal with it as recommended in connection with the removal of sequestra (see p. 444). Strict antiseptic precautions must be maintained throughout the treatment.

The fixation should not be continued too long; provided that the joints are not infected, daily passive movements ought to be begun as soon as the acute stage has passed off. The usual cause of stiffness of the joints is inflammatory swelling of the tissues around and not actual infection. Moreover, the muscles in the vicinity of the affected bone may become matted together and may render movement difficult. Therefore passive movement of the joints is desirable as soon as the acute inflammation has subsided. As healing progresses, the patient may be allowed to perform some movements himself; but the part should be kept elevated most of the day. Should any portion of the bone die, healing will not occur until the sequestrum has been removed (see p. 444).

Among the chief risks of acute osteo-myelitis may be mentioned septicæmia and pyæmia, and, in spite of free and early operation, the patient may succumb to one of these diseases. If symptoms of *pyæmia*, such as repeated and severe rigors occur, the main veins of the limb should be examined to see whether any of them are thrombosed, and if so, whether the affected portion can be cut off from the general circulation (see Vol. I. p. 193). In many cases, however, this cannot be ascertained, because the veins leading from the bone are deeply seated, and the thrombosis may not have extended to the larger vessels. Under such circumstances, amputation through the joint or bone above should be performed, as it offers almost the only chance of recovery. If a thrombosed vein be found in the amputation stump, it should be dissected out well beyond the clot and removed. Amputation is no doubt very dangerous when the patient is in this serious condition, but it is practically the only way of removing the septic clots thoroughly and satisfactorily, and hence often offers the only chance of saving the patient.

When the process is a *septicæmia*, amputation is not to be recommended because the infection is probably no longer local, and the operation would so weaken the patient as to prevent the body maintaining a successful struggle against the organisms. All that can be done is to see that the local conditions are made as favourable as possible, and to conduct the rest of the treatment on the lines already laid down in speaking of septicæmia (see Vol. I. p. 189).

Amputation.—Apart from the question of pyæmia, immediate amputation may be the best treatment in acute osteo-myelitis in old people, especially when we consider the age of the patient, the diminution in his resisting power, the length of time that will elapse before the separation of the sequestrum, the consequently prolonged suppuration, the serious operation that may be required for the removal of the sequestrum, and the length of time required for healing, which indeed may never occur. Amputation is also often necessary in cases of long-standing necrosis in old people (see Chap. XXIII.).

Resection of the Entire Diaphysis.—The periosteum of the diaphysis

may be separated from the bone from end to end, and if this be the case the whole shaft dies. This condition does not, however, necessarily demand amputation, for excellent results have been obtained by removing the dead diaphysis. For example, in the tibia, this can be done through an incision from one end of the bone to the other, and little more is required than to lift out the dead fragment. If the periosteum be still adherent to the bone anywhere, it should not be peeled off, but a thin layer of the surface of the bone should be removed with a chisel and left adhering to the periosteum in order to give a better chance of securing the formation of new bone. Even when the periosteum is separated by the inflammation, however, the deeper osteogenetic layer is often separated along with it and new bone will be formed. Should the diaphysis be still adherent to the epiphysis, a piece of the adherent diaphysis should be left, in the hope that a portion of the epiphyseal cartilage may remain undestroyed.

After the dead shaft has been removed, the greater part of the wound should be stitched up ; the edges of the periosteal tube should be approximated by sutures, and drainage tubes inserted at various points. Sometimes there may be almost complete reproduction of the shaft, especially if the precaution of chipping away a layer of the surface of the bone under any adherent periosteum be attended to. In some cases, however, this does not happen, either because the osteogenetic layer has been destroyed by the inflammation or has not been peeled off along with the periosteum, and then in the case of a child it becomes a question whether anything short of amputation is likely to be of use, since the epiphyseal cartilage is destroyed in these cases and no further growth will take place. The answer must depend upon the circumstances of the case and upon the particular bone affected.

Bone-grafting.—Of the various plans designed to obtain a firm limb after loss of the whole or the greater part of an important bone, bone-grafting has yielded the best results. It can only succeed, however, in an aseptic wound and, therefore, before it is attempted the wound must have been healed soundly for some time. The following are the steps of the operation.

A free incision is made over the deficient bone, the remains of the thickened periosteum are incised, and a bed is made for the new bone. It is better not to use a tourniquet, because it gives rise to prolonged after-bleeding, which is apt to separate the bone-grafts from the tissues ; the oozing should be stopped by pressure, the wound being carefully covered up while the grafts are prepared for insertion. The animal selected—preferably a young dog—is killed and rapidly skinned by an assistant and placed on an aseptic surface. With a fresh sterile knife and forceps, the muscles are rapidly peeled off a bone such as the humerus down to the periosteum, and a portion is removed with cutting pliers. The length of the individual grafts is not of much importance ; they can

be as long as the wound, but they must not be too thick or too broad, and, therefore, it is well to split the bone longitudinally into fragments with a stout knife. These fragments are laid in the wound after the bleeding has been arrested, until a sufficient amount has been introduced to fill out the groove to a reasonable size.

The soft parts are next brought together over the fragments by means of a few buried catgut sutures, and the wound is then closed without a drainage tube and the limb put on a splint. If the operation be done aseptically, no infection will take place, and the pieces of bone should gradually become welded together and united with the surrounding tissues. To some extent they may lead to the formation of new bone. Unfortunately, in a good many cases absorption goes on to such an extent that the bone-grafts become mere fibrous tissue and the limb becomes weak again, but in some instances very satisfactory results have been obtained. It is better to use bone from one of the lower animals than from another patient (for example, from an amputated limb), because of the possibility of transmitting disease thereby.

In some cases it is possible to use an autoplastic graft, a comparatively unimportant bone being sacrificed to replace one whose presence is indispensable. For example, the fibula may be fixed between the two ends of the tibia after destruction of the shaft of the latter. Experience shows that the slender fibula may increase in strength and thickness, and efficiently replace the stronger tibia.

Of Acute Epiphysitis.—When acute osteo-myelitis occurs near the epiphyseal end of a bone in a young child, the epiphyseal cartilage is apt to be destroyed completely, and no further growth of that end of the bone will occur after recovery. Should the epiphysis affected be the one from which the main growth of the bone is derived, material shortening of the limb may result.

The treatment of all the stages of acute epiphysitis is identical with that appropriate to acute osteo-myelitis (see p. 434).

Treatment of the Resulting Arrest of Development. The only point requiring special attention is the deficient growth of the bone afterwards. This condition not only gives rise to general shortening of the limb, but when one of two parallel bones is affected, troublesome deformity may arise. If for example the epiphyseal cartilage of the tibia or the radius be completely destroyed, the unaffected bone (*i.e.* the fibula or the ulna) continues to grow, and the foot or hand becomes deflected to the side of the damaged bone. When the disease occurs in infancy, complete uselessness of the hand or foot may result.

In order to prevent this, it has been proposed to *destroy the epiphyseal cartilage of the healthy bone.* The objection to this is that in the early stage of the disease it is impossible to be sure that the cartilage of the bone affected is really destroyed. Hence the method should not be resorted to in the early stage; but when two or three years have elapsed

and it is evident that no growth is taking place, it may be well to destroy the corresponding epiphysis of the other bone.

An alternative procedure is to allow the bone to grow and the deformity to take its course, and then *to excise portions of the growing bone*, so as to bring the foot or hand straight again. The choice between these procedures will be decided mainly by the age of the patient when first attacked by the disease ; in other words it will depend upon the length of time that must elapse between the time of the attack and that at which growth ceases, and, therefore, upon the degree of deformity likely to ensue. If, for example, several years must elapse, it is no good delaying operation until growth is complete. By that time the chances of getting a useful limb by taking out portions of the unaffected bone will be comparatively slight because the joint surfaces, the tendons, the muscles, and the other structures will have so altered and accommodated themselves to their new positions that they cannot be righted readily. Hence this method should be employed long before the bone has attained its full growth, and should be repeated if necessary.

When the disease occurs in young children, the question of *amputation* may have to be considered ; it must depend upon the prospects of obtaining a useful limb, which, in its turn, will depend upon the amount of destruction of the epiphyseal cartilage, and the share that the latter plays in the growth of the particular bone.

Of Acute Suppurative Osteitis accompanied by Joint Suppuration.—This is a grave condition which often ends fatally ; it is a combination of two serious affections—osteo-myelitis and acute suppurative arthritis.

Amputation.—In the majority of these cases the first thing to be considered is the advisability of amputation. If the patient be seen before he has passed into a hopeless septicæmic stage, amputation immediately above the affected joint is the best treatment. There is no need to amputate at any great distance beyond the joint affected unless the osteo-myelitis has spread into the bone above.

Apart from the septic dangers, amputation is often the best treatment, because, even if the limb were saved, it would be stiff, undeveloped, and useless afterwards. When the joint is infected, it is generally in association with acute epiphysitis, and, therefore, the patient recovers with a disorganised joint and an undeveloped limb if he survives the disease ; the two conditions combined will ultimately render the limb useless, especially if the patient be young when the disease occurs.

When the symptoms are not severe, it may suffice to make free incisions into the joint in addition to opening up the medulla as described above. This *arthrotomy* should expose every recess, and drainage tubes should be employed, and, if necessary, continuous irrigation or a water bath (see Vol. I. p. 32). Amputation must be performed, however, without loss of time if the symptoms do not improve rapidly under this treatment.

Of Acute Suppurative Osteo-myelitis and Periostitis after an Open Wound.—When acute osteo-myelitis follows an external wound —for example, an amputation, an excision, or a compound fracture—the organisms spread into and along the medulla and under the periosteum with great rapidity and almost certainly lead to necrosis of the whole thickness of the lower end of the bone, and very often to the formation of sequestra reaching upwards for some distance. The condition is very likely to be accompanied by pyæmia.

The best procedure, when acute necrosis follows amputation wounds, seems to be re-amputation of the limb. In compound fractures also, *amputation* should be done unless the osteo-myelitis be very limited. The re-amputation should be performed through the neighbouring joint or the bone above. It would be useless to amputate through the same bone, because there is generally not enough of it left to be of any value, and because it would be impossible to be sure of getting above the disease. Waiting for the separation of the sequestra in these cases is not to be advised, unless in exceptional cases.

Of Acute Suppurative Osteitis of the Flat Bones.—Acute suppurative osteitis is not very uncommon in the skull, the scapula, or the bones of the foot. In most of these instances, however, it occurs after an open wound.

The chances of recovery are extremely small in acute osteo-myelitis of the skull. The treatment must be on lines similar to those for the affection elsewhere. The details of the operation as applied to the skull will be found in connection with inflammation of the cranial bones (see Vol. III.).

When the whole scapula is affected, complete excision (see p. 528) is the best practice. When only a portion is attacked, all the bone visibly affected should be cut away. In the case of the small bones, such as the tarsal bones, excision of the affected bone may suffice if the inflammation be limited to it; but there is generally suppuration both of bones and joints, *e.g.* after a compound fracture or injury to the joints, and in these cases amputation is the only satisfactory remedy.

CHRONIC INFLAMMATION.

Chronic inflammation of bone may, on the one hand, affect chiefly the periosteum, and, on the other, the medulla and adjacent bone; it may follow the acute form, but is usually chronic from the first.

PATHOLOGICAL CHANGES.—In *chronic periostitis* there is great thickening of the periosteum and abundant formation of new bone beneath it, as well as condensation of the pre-existing bone, so that in chronic periostitis there is always a certain amount of osteitis. In *chronic osteo-myelitis* there is either softening of the bone, termed 'rarefying osteitis,' or condensation, termed 'condensing osteitis,' or a localised suppuration, termed 'Brodie's abscess of bone.' After a time the

inflammation extends to the periosteum, so that the case is a combination of chronic osteo-myelitis and chronic periostitis, and, therefore, the treatment of these two conditions cannot be separated. Chronic inflammations usually commence without acute symptoms, sometimes after an injury, possibly in connection with some constitutional condition, or under other circumstances that we do not exactly understand. We exclude here the chronic inflammation of bone dependent on tuberculosis, syphilis, and possibly rheumatism, though some of these chronic forms may be of so-called rheumatic origin.

In chronic osteo-myelitis going on to rarefying osteitis an abscess may occasionally arise, and the rarefying osteitis may extend through the whole thickness of the dense bone, so that an external opening forms. If this be insufficient for the escape of the pus, the chronic inflammation of the bone still persists. Similarly, chronic inflammation may go on after successful removal of a sequestrum when there is not a sufficient exit for the discharge from the cavity.

SYMPTOMS.—There is thickening of the bone, tenderness over the inflamed part, and often severe pain when the limb becomes warm, especially at night in bed. Tenderness is usually more marked in chronic periostitis than in chronic osteo-myelitis. In the latter affection, on the other hand, pain is more marked than tenderness and is of a neuralgic character. In both diseases the symptoms may subside for a time, but are liable to exacerbations, particularly in the chronic abscess of bone ; in this affection the patient may be comparatively free from pain for months and may then suffer from a severe attack. Radiograms should be taken to show the extent of the disease on the surface of the bone and the condition of the medulla. When an abscess is present a cavity will be seen in the bone, and this information is of great value in deciding the extent of the operation.

TREATMENT.—The treatment may be palliative or operative. We shall mention the former first, as a patient will seldom submit to operation in the first instance.

Palliative.—This consists firstly in rest ; secondly, in elevation of the limb so as to improve the circulation ; thirdly, in the employment of counter-irritation, either in the form of blisters or the actual cautery, especially Corrigan's (see Vol. I. p. 21) ; and fourthly, in the administration of drugs, of which the most useful are iodide of potassium, aspirin, salicin, or salicylate of soda. Large doses of iodide of potassium will often relieve the pain very markedly, even in cases of a non-syphilitic origin ; ten grains should be given three times a day at first, but the dose should be rapidly increased up to twenty or twenty-five grains.

Palliative treatment is almost always only temporary in its results ; a cure rarely results, even though the treatment be carried out for many months. As a rule, the condition improves for a time and then relapses,

for reasons that are not clear. Even when iodide of potassium exerts considerable influence, the large doses must be continued for a long time, as the disease is very apt to recur as soon as the drug is left off.

Operative.—**In Young Subjects.**—If the disease persists after a trial of these measures, it is advisable to deal freely with the affected area in the following manner. The milder measure of making a free incision through the periosteum down to the bone is not of much practical use; it may relieve the pain for a time, but it recurs soon after the wound has healed, and something more radical is required.

Removal of Periosteum and Gouging of Bone.—It is best to divide the periosteum over the whole area of thickening, and to remove all of it that lies over that area. The new periosteal bone is next gouged away over the same region, and then a groove is cut in the bone towards the centre of the inflamed portion until the medullary cavity is opened. Should the case be one of osteo-myelitis with abscess, the abscess cavity will almost certainly be opened during the operation.

It is not clear how the gouging of the inflamed bone leads to such remarkable relief and often to complete cure, seeing that all the inflamed part is not removed; but if a cure is to be obtained, it can only be looked for after free removal of the thickened periosteum and the inflamed bone. It has been proposed to bore holes with a bradawl, or to use a small trephine, but these methods have nothing to recommend them as compared with the free removal of bone. Moreover, it is very easy to overlook an abscess cavity unless the bone be opened up very freely.

Drainage of an Abscess.—When an abscess cavity is exposed, it should be opened thoroughly so that no recess is left, and the opening in the bone leading into it should be as large as, if not larger than, the abscess cavity itself; any sequestrum present should be removed, the lining membrane of the abscess should be scraped away, and with it should be removed some of the condensed bone which forms its wall. There is no necessity to pack the wound or apply any antiseptic, because even in the case of chronic abscess of bone it is questionable whether the organisms causing the abscess are alive; in any case they are certainly not virulent.

When the bleeding has been arrested, the soft parts can be brought together and the skin stitched up; if free oozing be going on, it is well to introduce a small drainage tube at the lower part of the incision, but this should be removed in a day or two. The cavity in the bone becomes filled with blood and healing occurs by organisation of clot. In order to obtain as vigorous a clot as possible, it is well not to pour lotions of any kind into the wound after the operation has been completed; it is well also not to make a vertical incision over the part, but to employ the flap method. In the tibia, for instance, a large flap with the convexity backwards may be turned forwards so as to expose the whole bone; the incision will then lie nowhere over the gouged cavity in the bone, which will be all the more likely to heal readily on that account.

After-treatment.—The limb should be placed on a splint and kept at rest for three or four weeks. Unless rest be enforced, the delicate clot which fills up the cavity is apt to break down. For the same reason the patient should not be allowed to walk until two months have elapsed, when the lower extremity is affected. These operations should be conducted strictly aseptically: were sepsis to occur very grave suppurative osteo-myelitis or periostitis might ensue.

This treatment is the best in all cases of inflammation limited to a portion of the bone occurring in young people. When the inflammation affects the whole bone, the results are not so satisfactory, as a very extensive operation must then be done, a groove being made throughout the whole bone, and much periosteum taken away.

In Old People.—When the affection is extensive and when it occurs in old people, it is a question whether the line of treatment recommended above is allowable or will suffice. When the whole of a bone is involved, the periosteum can only be removed from one side and there is no guarantee against recurrence, because a large portion of the bone will not have been touched.

Amputation.—Cases occur in which the pain is so excessive and long continued, and leads to so much agony and loss of sleep, that the patient will submit to anything rather than allow it to go on. In old people it then becomes a question whether amputation will not give a better result when a large area of bone is involved. Amputation will certainly cure the disease—unless neuritis has been set up—and there will be complete relief of pain, and absence of recurrence after an operation which, in old and feeble patients, is less dangerous and is followed by a much more rapid recovery than that just described.

CHAPTER XXIII.

NECROSIS: PHOSPHORUS NECROSIS.

NECROSIS of the bone follows acute suppurative osteo-myelitis and periostitis, and may also result from tuberculous disease, syphilis, or the action of phosphorus. We shall only consider here the necrosis which follows acute osteo-myelitis and the form resulting from the action of phosphorus.

NECROSIS FOLLOWING ACUTE OSTEO-MYELITIS.

Characters of the Sequestrum.—The sequestrum presents the character of normal bone which has died before there has been time for the inflammation to produce any alteration in it. It is usually the compact tissue that dies, and the sequestrum may consist of the whole thickness or only part of this. Towards the periphery the bone is pitted, portions of living bone being separated with the periosteum.

Separation of the Sequestrum.—Sooner or later a piece of dead bone must become separated from the living portion, and the process of separation varies in rapidity according to the bone affected; the process of separation may take from six weeks to six months. While separation is going on, condensation of the bone around takes place, and new bone is rapidly formed from the periosteum and may progress to such an extent in the long bones of young persons that the dead portion becomes enclosed in a thick shell of bone before complete separation has taken place; openings called 'cloacæ' leading to the sequestrum are, however, left here and there in the new bone. In old people there is rather a stalactitic formation around the necrosed fragment than a true enclosure by bone. In the flat bones, such as the skull, the production of new bone is not nearly so marked, and there is seldom anything like complete enclosure of the dead fragment in a bony cavity.

The result of this formation of new bone is that the necrosed bone can rarely be got rid of without operation. Sometimes small fragments become broken off and are pushed to the surface by the granulation

tissue, but the main mass still remains, and as long as the sequestrum is present, suppuration and the inflammatory condition of the bone around persist, so that there is steadily increasing condensation of the bone, and fistulæ are formed which often traverse the skin for a considerable distance, and along which a probe can be passed through the cloacæ on to the sequestrum. It is often impossible to make out whether the latter is loose or not, because the cavity in which it lies is too small to permit of movement, or because the sequestrum is large, or because it is convex and represents a great part of the surface of the bone; but we know that the dead fragment will be loose in any case, if six months have elapsed since the acute attack.

TREATMENT.—The treatment consists in removing the dead bone as soon as it is loose, and then dealing with the cavity left. Until the sequestrum has become loose, the sinuses should be dressed with boric ointment. There is no object in operating until the dead bone has become loose, and in many cases the time for operating must be determined by the time that has elapsed from the commencement of the trouble rather than by the mobility of the sequestrum. It is not advisable to operate on patients suffering from necrosis soon after the acute symptoms have subsided, since the dead fragment cannot then be loose, and it would be quite impossible to know how much is dead and how much, therefore, ought to be removed.

Sequestrotomy.—When possible, it is well to control the circulation with an Esmarch's bandage, partly because a good deal of blood would otherwise be lost in a prolonged operation, and partly because it is difficult to disinfect the part if oozing is going on. When the necrosis is high up in the limb it will not be possible to apply the bandage satisfactorily, and the increased after-bleeding may also be an objection to its use. Nevertheless, it is best to employ it whenever possible; the after-bleeding may be checked by plugging the wound firmly before the bandage is removed.

Removal of the Sequestrum.—Before operation the position and extent of the sequestrum should be ascertained by means of a radiogram, which will often assist the surgeon to plan his incision so as to approach the sequestrum by the best route. The incision must be planned so as to avoid injury to important structures, more especially nerves, but it must afford complete access to the part, and must be enlarged if required during the course of the operation. It need not necessarily be in the vicinity of the sinuses, which may be disregarded if better access can be obtained from another part of the limb. All the soft parts, including the periosteum, are divided down to the bone, and the former structure is peeled off with a rugine as freely as may be necessary. If one of the cloacal openings in the bone be exposed in the wound, the new bone is gouged or chiselled away, beginning at this opening, but no attempt should be made to remove the sequestrum until it has been

exposed thoroughly. Attempts to extract it through too small an opening are sure to result in fracturing it, and then fragments are almost certain to be left behind which may be difficult to find afterwards ; if left behind they will prevent the wound from healing.

If the area of bone exposed be not that in which the cloacæ are present, the exposed portion should nevertheless be chiselled away until the cavity in which the sequestrum is lying is reached, and then the opening should be enlarged to any extent that may be necessary. The most difficult cases are those in which the necrosis has involved a considerable segment of the bone, and the sequestra are curved, so that a single opening in the bone will not suffice for their removal. It may then be necessary to make an incision on the opposite side of the limb and chip away bone there, and then possibly to break the sequestrum in two, and remove part through the one incision and part through the other. The important points are to obtain free access to the cavity, and to remove the sequestrum in one piece if possible.

Disinfection of the Cavity left.—After the whole of the sequestrum has been removed, the granulation tissue in the cavity is scraped away in order to make sure that no small sequestrum is left behind among the granulation tissue ; removal of the granulation tissue also increases the chance of getting the wound aseptic, and thus eradicating the sepsis. In order to facilitate the disinfection of the wound, the cavity should be soaked with undiluted carbolic acid, and any sinuses present should be treated similarly. The best treatment for these septic sinuses, however, is to excise them completely if their situation renders this possible. The tourniquet should now be relaxed and any spouting vessels tied. If the oozing from the bone and the tissues be severe, it may be necessary to plug the wound tightly with gauze, and elevate the limb.

Obliteration of the Cavity.—Healing does not necessarily follow removal of the sequestrum ; if the dead bone be removed through a comparatively small opening, the cavity in the bone may never close, as the opening in the soft parts contracts rapidly, and long before the cavity has become filled up with granulations, the exit from it has become so small that the discharge cannot escape freely. When this condition has become established, the cavity will suppurate just as if a sequestrum were present, and it is impossible to keep it properly open and very difficult to keep anything but a metal drainage tube in it. Hence, in order to get healing, not only must all sequestra be removed, but also, if possible, perfect drainage must be established for any cavity that is left. To secure this, as free an opening should be made into the cavity as is practicable, short of endangering the strength of the bone ; the sides of the cavity should be bevelled away so as to leave a wide shallow depression in the bone, instead of a deep narrow cavity. When this can be done in deep-seated bones, such as the femur, the periosteum and soft parts may fall over and adhere to the raw surface. In more

superficial bones like the tibia, the skin and soft parts may be brought over and pressed down so as to line the cavity throughout. A large antiseptic dressing is applied and bandaged on firmly in order to arrest all oozing and to press the soft parts well down on to the bone.

After-treatment.—This will vary according as the cavity can or cannot be obliterated.

(*a*) *When the cavity can be obliterated*, a drainage tube should be inserted, the wound stitched up, the ordinary antiseptic dressings applied and the limb placed on a splint for a week or two. The splints should be left off as soon as the wound in the skin has healed, and the patient encouraged to move the limb in bed, while at the same time passive motion should be practised, otherwise the muscles are apt to become adherent to the raw surface of the bone, in which case free movement of the neighbouring joints will be interfered with. It is well, however, not to allow the patient to hang the leg down or to walk until the wound has quite healed, especially when the tibia is affected; in the case of the upper extremity, however, the patient may be allowed up as soon as he has recovered from the effects of the operation.

(*b*) *When the cavity cannot be obliterated.*—When the above procedure is impossible and a cavity must be left, it may be treated by continuous drainage if it be septic, or, if the surgeon be successful in making it aseptic, by filling it up with some material that may afterwards organise or act as a mould for blood-clot. The choice between these two plans depends on the question of asepsis.

It must be confessed that more often than not the attempt at complete disinfection of these wounds is a failure, and under such circumstances the length of time required for closure of the cavity in the bone left after removal of a sequestrum is very great and in many cases, especially in deeply seated bones, healing never takes place. In all cases, however, the attempt to disinfect the cavity must be made. We have already referred to the use of undiluted carbolic acid after thoroughly scraping out all recesses of the cavity; other antiseptics such as formalin, and various caustics such as nitric acid are also employed. Heat has also been used, the whole interior of the cavity being cauterised by a cautery, or hot air being directed over its wall. These various attempts are made while the tourniquet is still applied. After a time the tourniquet is taken off, when the result is that the antiseptics are diluted and washed away with the blood, and oozing from any larger vessels in the bone can be arrested by the use of Horsley's aseptic wax (see p. 146). After the bleeding has practically stopped, the wound should be stitched up, small intervals being left between the stitches to permit the excess of blood to escape, the usual antiseptic dressings applied, and the limb placed at rest on a suitable splint.

In the course of three or four days it will be evident whether the attempts at disinfection have succeeded or not. If they have, the wound

remains quite quiet, the blood-clot remains solid and gradually undergoes organisation into fibrous tissue and the skin wound heals. If the attempt fails, the wound becomes painful and red, the blood-clot breaks down and healing by first intention does not occur.

When the wound remains aseptic, it is worth while to try to get organisation of blood-clot in it. Under such circumstances one may be content to leave things alone, and trust to the organisation of the blood-clot as referred to in the preceding paragraph. It not uncommonly happens, however, that, while organisation goes on to a considerable extent, some of the clot becomes fluid and a collection of serum gradually makes its way out through the scar and leaves a sinus which does not always remain aseptic.

Hence with a view of getting a better clot, various substances, of which the chief are catgut, decalcified bone or a mixture of iodoform and paraffin have been left in the wound to assist the clotting.

Of these, decalcified bone and the iodoform and paraffin mixture are the best. The bone is cut into small pieces, decalcified and placed in absolute alcohol until just before use, when it is immersed for some minutes in sterile salt solution. Decalcified cancellous bone is better than the compact tissue when it can be got ; it is lighter and more porous and thus forms a supporting medium. It should be well squeezed and then packed into the cavity in small fragments pretty close together, until the cavity is filled up to the level of the periosteum, before the tourniquet is relaxed. The periosteum is then brought together by catgut sutures, as close as it will come over the cavity. When the bone is deep-seated, it is well also to bring the muscles together with catgut stitches. If there be free oozing, a small drainage tube should be inserted at the lower end of the wound for the first twenty-four hours, but a drainage tube is unnecessary when the oozing is slight. Antiseptic dressings are applied and the limb is placed upon a splint.

The result of this in an aseptic wound is healing by first intention, and the blood-clot between the fragments of bone becomes penetrated with cells which find their way also into the decalcified bone, so that ultimately the whole cavity is filled with young tissue which gradually organises into fibrous tissue. This method is much the most rapid and satisfactory, but is only effectual in an aseptic wound.

At the end of three weeks the splint should be left off, and the patient allowed to move the limb in bed. Only slight movement must be permitted at first, as otherwise the organisation of the grafts may be interfered with. As much movement as the patient cares to do in bed will not usually do any harm. It is important to promote early movement, for not only are the movements of the neighbouring joints apt to be impeded by the occurrence of some synovitis, but the muscles are specially likely to become adherent to the edges of the cavity in the

bone. As time goes on, passive motion should be made by the surgeon daily. At the end of about eight weeks, the patient may be allowed to get about; but even then, the limb should not be allowed to hang down for any lengthened period. Massage should not be employed until three months have elapsed since the operation, and only then if it be necessary to increase the power of the muscles. Generally, however, it will not be necessary and, if not absolutely required, it is better to avoid it, because the new material is still very tender and might break down from very slight violence.

In the case of the iodoform and paraffin, it should be softened and then tightly packed into the cavity until the latter is quite full; the periosteum and skin are then closed as above. If this succeeds, it will be found that the iodoform and paraffin gradually disappear and its place is taken by young fibrous tissue and later by bone.

These methods are, of course, only successful if the wound remains aseptic and this cannot be foretold at the time of the operation. Hence, whenever it seems to the surgeon that he has been able to deal thoroughly with all the recesses of the cavity and that there is a good chance of an aseptic wound, he should employ the methods just described with the view of hastening the closure of the cavity. If the wound does not remain aseptic he must clear out the clots and foreign materials and deal with it in the following manner.

(*c*) *When the wound becomes septic*, it should be opened up, the clots, cleared out and the cavity washed with sterile salt solution or with weak sublimate lotion (1 in 6000 or 8000).

The wound is left widely open and packed with cyanide gauze, substituting large drainage tubes for the gauze on the fourth or fifth day. Long before the cavity in the bone has filled up, however, the hole leading into the cavity will have become so small that a rubber drainage tube cannot be maintained, while the skin gets drawn in so as to form a gutter, at the bottom of which a small opening leads into the cavity in the bone When this condition is reached, the opening must be enlarged and the sides of the gutter cut away, so as to allow a large drainage tube to be inserted, drainage tubes of silver, aluminium or lead, as advocated by Mr. Charters Symonds, being employed; the granulations which have already formed in the cavity should not be disturbed. The metal tube must be taken out every few days to be cleaned and must not be dispensed with until the cavity has closed completely, which may not be for many months.

The formation of the gutter can sometimes be avoided by stitching up the wound and bringing the drainage tube out at the side, but this gives no advantage as regards the healing of the cavity. These difficulties emphasise the great advantage of cutting away the edges of the cavity and obliterating it as far as possible in the first instance, and this should therefore always be done if possible.

These patients are usually very debilitated by the previous acute illness and the prolonged suppuration following it, and they should be placed on a generous diet and given suitable tonics ; if possible they should be sent to the country, and if unable to walk they should be wheeled out in the open air as much as possible. In all cases of long continued suppuration after necrosis, it is well to examine the urine frequently for albumen. When once the sepsis has been eradicated, the albuminuria, which is usually due to amyloid degeneration, will commonly pass off as the wound heals.

Amputation.—The foregoing refers to the treatment of sequestra in young people. In patients who are over fifty-five the problem is different, because obliteration of the cavity will hardly be likely to occur after removal of the sequestrum and it is very important for the old to get well as soon as possible. Hence it seems to us best to amputate the limb when the necrosis is extensive or affects the lower extremity, whether the necrosis follows a compound fracture, an amputation, or some acute disease in early life. Attempts to get the cavity to fill up after removal of the sequestrum are liable to end in disappointment ; and it must not be forgotten that the operation of sequestrotomy is often severe and accompanied by shock and considerable loss of blood, which may lead to very serious consequences in people of advanced age. The after-effects of the operation are certainly more severe after a bad sequestrotomy than after amputation, so that, both from the point of view of rapid healing and of the safety of the patient, amputation is the better practice. Another point of importance is that when a sequestrum has remained *in situ* for many years, severe albuminuria is often present, and in such cases it is safer to amputate than to remove the sequestrum.

QUIET NECROSIS.

Sir James Paget described a condition that he called ' quiet necrosis,' in which death of portions of bone occurs without any violent inflammation and without the formation of sinuses. These cases are rare, and it is probable that some of them are really cases of tuberculous disease of the bone, while others are complications of enteric fever. We have met with cases in which a sequestrum lay in the middle of much thickened bone, without any suppuration around.

TREATMENT.—The only interest in the condition from the point of view of treatment is to remember that when thickened bone, resulting from chronic inflammation, is being operated upon, the possibility of finding a sequestrum or a chronic abscess in the centre of the enlarged area should not be lost sight of ; if a sequestrum be found, it must be removed. If a deep cavity be left in the bone, bone-grafts may be introduced immediately ; or it may be left to heal by blood-clot (see p. 446). In any case the wound should be closed without drainage, and immediate healing will probably result.

PHOSPHORUS NECROSIS.

Phosphorus necrosis requires special mention as it differs in some respects from the necrosis due to other causes. It is the yellow phosphorus, not the red, which produces necrosis, and practically the lower jaw is always the bone affected. The disease is probably purely local; the phosphorus comes into contact with the bone through the medium of carious teeth. The gums become ulcerated and the inflammatory affection spreads to the periosteum and thus leads to the formation of spongy outgrowths from the bone. The gums become separated from the alveoli, fœtid pus is constantly poured out, and a large area of the jaw or even the entire bone may lose its vitality. The sequestrum, therefore, is not merely normal bone that has died, but consists of the original bone with large spongy osteophytic growths on the surface.

The researches of Prof. Ralph Stockman[1] seem to show that the condition is really tuberculous, and that the phosphorus merely predisposes the tissues to tuberculous infection.

TREATMENT.—*Prophylaxis.*—The first essential is to see that the patient works only in the red or amorphous, and not in the yellow form. The most scrupulous care should be taken to wash the hands thoroughly before meals, because it is probable that the mischief is due to particles of phosphorus coming into contact with the food, rather than to the actual phosphorus vapour. Another point of the first importance in prophylaxis is that the gums and teeth should be carefully watched while the patient is at work, and at the first sign of ulceration the work should be given up, and antiseptic washes, such as Sanitas or Condy's fluid, used until the ulceration is cured; any carious teeth should receive appropriate treatment. The hygiene of the mouth is of the first importance.

When the Disease is established.—Working in phosphorus should be abandoned at once. There are two alternatives in treatment, viz., either to wait for the separation of the necrosed fragment, or to excise the affected portion of the jaw at once, leaving the osteogenetic layer of the periosteum intact as far as possible. The separation of the sequestrum in these cases is extremely slow, and a very long time may elapse before the affected portion becomes loose; as a large portion of the jaw will almost certainly be destroyed, it seems best to remove the affected portion of the bone directly necrosis is established, especially in view of the probable tuberculous nature of the affection. If the periosteum be separated carefully, sufficiently firm bone will usually be thrown out to make a useful mandible. The operation of excision of the mandible is described in connection with the affections of that bone (see Vol. III.).

[1] *Brit. Med. Jour.*, January 7th, 1899.

CHAPTER XXIV.

TUBERCULOUS DISEASE OF BONE: ACTINOMYCOSIS.

TUBERCULOSIS.

VARIETIES.—Tuberculous disease of bone is most common in young people. The bone is generally affected either in the epiphysis or in the shaft just outside the epiphyseal line. In some cases the medulla may be attacked, while in others the disease may begin beneath the periosteum. The affection may assume the following forms.

Acute Tuberculosis of Bone.—This may occur in the course of a general acute tuberculosis, or the disease may be limited to one bone, in which case it starts in connection with a pre-existing tuberculous deposit. The form met with in acute general tuberculosis is of no importance from the point of view of treatment; when the acute affection is limited to one bone, it influences the treatment in so far that nothing short of removal of the affected bone is likely to do any good.

Limited Tuberculous Deposits.—These are found most frequently in the epiphyses, though in some places, notably the head of the femur, they may be extra-epiphyseal; they may occur as soft caseating deposits in which the bone trabeculæ have more or less completely disappeared, or as sequestra imbedded in tuberculous material.

When there is a *limited caseating deposit* in the end of the bone, the tendency is for the disease to spread gradually and for the softening of the bone to continue until the deposit reaches the surface. Its further progress then depends upon whether the spot at which it reaches the surface of the bone is inside or outside the joint. In the former case the articular cartilage over the deposit is destroyed, a communication is formed with the joint, and the result is rapid infection of the synovial membrane. These cases are considered in connection with tuberculous disease of joints (see Vol. III.).

When the tuberculous deposit reaches the surface outside the capsule of the joint, the periosteum becomes infected, and the tendency is for the soft tissues outside to become attacked, and for a chronicabscess

to form. At the same time that the tuberculous deposit is making its way to the surface, the periosteum in the vicinity is becoming thickened and new bone is being deposited, so that the bone usually becomes considerably enlarged.

Tuberculous sequestra are usually somewhat wedge-shaped, with their bases either beneath the articular cartilage or on the free surface

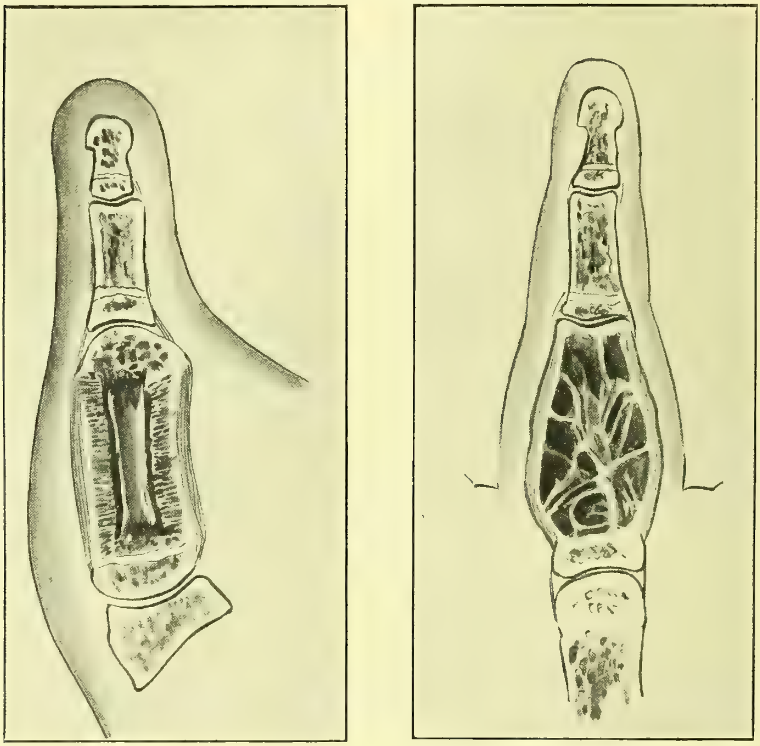

Fig. 212.—Tuberculous Dactylitis. Diagrammatic vertical sections to show the two types of the disease. In the right-hand figure the proximal phalanx of the index finger is seen rarefied and expanded; in the left-hand one the shaft of the proximal phalanx of the thumb has necrosed and is surrounded by a sheath of new bone.

of the bone. Their further progress is similar to that of the caseating deposit just described. An abscess may then form outside and burst. When the abscess is opened or bursts spontaneously, a probe passes down into contact with a dense tuberculous sequestrum. The characters of a tuberculous sequestrum will be found on p. 454.

Tuberculous Osteo-myelitis.—Here the medullary tissue is infiltrated with tuberculous material. This condition specially affects the shorter of the long bones such as the phalanges and metacarpal bones; it may end in the formation either of a soft caseating mass, or of sequestra as

well. In the fingers it is known as 'strumous dactylitis.' At first the disease is confined to the interior of the bone; during this time the periosteum around becomes thickened, and when the bone is short, like a phalanx, it becomes fusiform. As the disease progresses, however, the hard shell of the bone is broken through at some point, and then infection of the periosteum occurs. Subsequently a chronic abscess forms which, when opened, is found to lead into the interior through a hole in the bone.

Tuberculous Periostitis.—In this form the tuberculous material is deposited beneath the periosteum; it occurs specially frequently in the ribs and the vertebræ. The disease spreads partly into the bone and partly into the soft tissues around, and an abscess frequently forms; the surface of the bone becomes eroded and carious, and small sequestra may form. In the ribs spontaneous fracture may occur.

CLINICAL STAGES.—*Tuberculous osteitis* may be met with in various clinical stages. In the first place, the tuberculous deposit may be still confined to the interior of the bone, and no external infection may have occurred. Secondly, the deposit may have reached the surface of the bone and have caused a chronic abscess over it; and thirdly, this chronic abscess may have burst, and septic sinuses may be present leading down to a tuberculous deposit in the bone.

In *tuberculous osteo-myelitis* the condition may also be similar. In some cases the bone is enlarged but still intact; in others there may be abscesses in connection with the enlarged bone, and in a third class there may be sinuses leading down into the medulla.

In *tuberculous periostitis* there will be thickening of the periosteum in the early stages, but in exposed bones, such as the ribs, there may be a chronic abscess early in the case, or the abscess may have burst before the case comes under notice, leaving sinuses leading down to carious bone. The results in the cases in which deposits open into joints are dealt with under Tuberculous Disease of the Joints (Vol. III.).

TREATMENT.—The details of treatment depend to a considerable extent on the bones or parts of the bones involved. Here we can only deal generally with the subject, taking one or two of the cases as examples.

It is not necessary to describe the treatment of tuberculous deposits, tuberculous osteo-myelitis, and tuberculous periostitis separately; it will suffice to take the three clinical divisions: (1) tuberculous disease of bone without abscess; (2) tuberculous disease of bone with abscess; and (3) tuberculous disease of bone with septic sinuses.

Of Cases unaccompanied by Chronic Abscess.—Here the chief difficulty is to diagnose the existence of tuberculous disease at all. The surgeon must be guided to a great extent by the history of the case, by a previous or hereditary history of tuberculosis, by enlargement of the bone without any marked symptoms, by the general character of the enlargement, and by the fact that the part affected is a common seat

of tuberculosis. In certain cases, such as strumous dactylitis, there need be little hesitation, the only other possibility being syphilitic disease. Radiography is often of great value in these cases, as alterations in the structure of the bone can be identified and sequestra demonstrated by its aid.

Palliative Measures.—When the diagnosis has been made, the surgeon has to make his choice between palliative and radical measures. Palliative measures comprise rest, counter-irritation, pressure and good hygienic conditions, cod-liver oil, syrup of iodide of iron, etc., which have already been referred to in connection with tuberculous disease in general (see Vol. I. p. 231), and are also referred to under Diseases of Joints. In strumous dactylitis particularly, palliative measures are very useful, and many cases recover if treatment be persevered with steadily for several months ; it is seldom that an operation is necessary or advisable, unless an abscess forms. In the case of other bones, counter-irritation, especially by means of the actual cautery (see Vol. I. p. 20), is often very useful.

Radical Measures.—When the deposit is in the articular end of a bone, it is very liable to open into the joint and infect it, and therefore it is advisable to get rid of it as soon as possible. A radiogram is a most valuable aid in deciding whether a deposit of this kind is present ; if it is, the best treatment is to remove it without delay. The incision should be so planned that it does not open the joint, because it is important to avoid infecting it with tuberculous material. The incision should expose the bone where the thickening is most marked ; if a tender spot can be detected, it should always be cut down upon, because there the deposit is probably nearest to the surface of the bone. A flap, consisting of skin and subcutaneous tissue, is turned aside and the bone exposed ; if the periosteum be unaffected it should be incised and peeled back, and then the surface of the bone is removed with a gouge. If a caseous deposit be present, unduly soft bone is soon encountered ; if, on the other hand, there be a sequestrum, the bone will be extremely dense.

In the case of *a soft deposit*, all the tuberculous material should be scooped out with a sharp spoon until a cavity with fairly firm walls is left, and then a thin layer of the denser bone which forms the wall of the cavity should be taken away by a stronger spoon or a gouge. For this purpose Barker's flushing gouges (see Vol. I. p. 156) are very useful. Microscopical examination shows that the disease seldom extends more than an eighth of an inch into the bone beyond the actual soft deposit, so that only a thin layer need be removed. It is, however, important to remove this as otherwise tuberculous disease may be left behind.

If a sequestrum be met with, it must be taken away. The characteristics of a tuberculous sequestrum are that it consists of thickened bone, and is thus heavier and harder than the normal bone ; but at the same time it is not very firm and usually crumbles under the fingers. Tuberculous

sequestra are very slow in separating, and months or years may elapse before a small sequestrum is quite loose. The sequestrum, therefore, cannot be lifted out as can those that follow acute osteo-myelitis, but must be torn out of its bed with forceps. The wall of the cavity from which the sequestrum has been removed is also tuberculous, and must be scooped and gouged away in the manner described above for the removal of soft deposits. Strict asepsis is essential, as otherwise serious suppuration may occur, and then any tuberculous tissue left behind is likely to grow more rapidly.

If the whole of the tuberculous tissue has been got rid of, it will suffice to stitch up the wound, leaving the cavity to fill with blood-clot which subsequently becomes organised; but if there be any doubt about the complete removal of the tuberculous deposit, it is better to apply undiluted carbolic acid to the part, sprinkle the wound with iodoform, and pack it with cyanide gauze impregnated with iodoform. On the following day the external dressing is removed, but the packing need not be disturbed for three or four days unless it be loose. This packing is continued until the wound has completely filled with granulations, and then it may be given up and the ordinary dressings applied until healing is complete.

In tuberculous disease of the small bones such as those of the tarsus, it is often best to excise the bone in the early stage without attempting merely to remove the deposit. The removal of one of the cuneiforms, for example, does not in any way cripple the patient, and if done in the early stage it cuts short the disease—which otherwise would be apt to spread to and infect the tarsal joints—and gives an excellent functional result. This subject is fully considered in connection with diseases of the tarsus (see Vol. III.).

Of Cases in which there is an Unopened Abscess.—The abscess may originate in connection with either tuberculous periostitis or deposits in the interior of a bone which have made their way to the surface. The best treatment, when it can be done, is to excise the abscess as if it were a cyst, and at the same time to remove the diseased periosteum along with the superficial layer of the bone, or to clear out any deposit that may be present in the interior.

Excision of an Abscess connected with Bone.—A good example is tuberculous disease of a rib; in the ribs the majority of cases commence in the periosteum, and are examples of tuberculous periostitis. When the abscess is large it is not always possible to be sure at first which rib is affected. A free incision is made over the abscess, parallel to the rib, the skin and subcutaneous tissues are turned aside, and the muscular fibres separated from the abscess wall. This, however, is not always possible, for the muscle may be involved in, or adherent to, the abscess wall. In the latter case the muscular fibres are divided, and the abscess is carefully defined without puncturing it, until it is ascertained which rib it is attached to. This rib is then exposed beyond the limits of the

abscess, and cut across by cutting pliers on each side, so that the intervening diseased portion can be removed along with the abscess over it. When the rib has been lifted out, a cavity containing tuberculous material is generally found beneath it, for the pus usually surrounds the rib. This part of the wall cannot be dissected away, but should be thoroughly scraped without damaging the pleura. The wound is then washed free of any tuberculous material that may have lodged in it, and stitched up. If all the tuberculous material has been removed, healing by first intention occurs, whereas if the abscess had been merely opened, scraped out, and glycerine and iodoform injected, the disease might go on for months, and spread to inaccessible parts or from one rib to another.

When this treatment can be adopted in other bones it should be done.

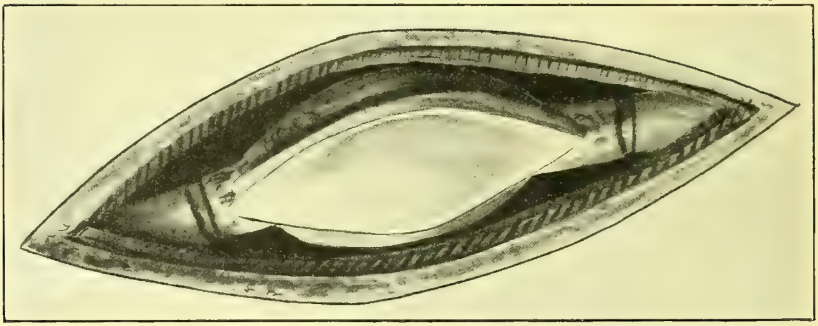

Fig. 213.—Method of Excising a Tuberculous Abscess of the Rib. The skin is left adhering to the abscess cavity and the periosteum has been divided well beyond the abscess at each end, preparatory to cutting through the rib.

For example, when there is an abscess in connection with a tuberculous deposit in one condyle of the femur, a curved incision should be made over it, the flap thrown back, and the abscess wall dissected out as far as possible. After removing this, the hole in the condyle is searched for, the bone cut away all round it, and the deposit removed in the manner already described (see p. 454).

When the abscess is very large, or when from its connections it cannot be dissected out, it should be laid freely open, as much of the abscess wall as possible removed with scissors and forceps, and any portions left behind thoroughly scraped. The diseased bone is then exposed and removed. After this the wound can generally be stitched up and healing by first intention secured without further trouble. When the complete removal of the tuberculous tissue is doubtful, it is well to leave the wound open, sponge it out with undiluted carbolic acid, and stuff it with cyanide gauze sprinkled with iodoform.

In strumous dactylitis with abscess, which may be taken as representing tuberculous osteo-myelitis in the shafts of bones, similar treatment

should be employed. It is often tempting to amputate the finger or the toe, but this is not usually necessary. If the abscess wall be removed, and the medulla well scraped out, the wound will usually heal without trouble.

In abscesses connected with deep-seated bones, such as the spine or pelvis, the treatment must be conducted on the lines laid down for chronic abscess (see Vol. I. p. 233). In the majority of the patients that come under the notice of the surgeon in hospitals and in large towns, opening the abscess is the usual method. The abscess is opened, the wall thoroughly scraped, the cavity washed out so as to get rid of all the flakes of cheesy material, and then a 10 per cent. emulsion of iodoform and glycerine (see Vol. I. p. 234) injected and the wound closed. In some cases the deposit may be scraped out and rapid healing obtained, but as a rule this is only likely in cases of tuberculous periostitis. When there is a tuberculous sequestrum or a soft deposit in the bone, the abscess is apt to re-form and the final result is doubtful. In these cases, however, recent experience has shown that, if the patient can be put under the most perfect hygienic conditions in pure country air, incision of the abscess is not absolutely necessary ; simple aspiration may suffice.[1] This matter is dealt with more fully in connection with affections of the spine.

Of Cases in which there are Septic Sinuses.—Here there is little tendency to healing, and suppuration may go on indefinitely unless the condition can be improved by operation.

Excision of Sinuses.—The sinuses may be excised, the area of bone from which they originated being freely exposed and the focus of disease removed, if possible. Every attempt should be made to render the wound aseptic. The skin should be thoroughly disinfected, and the granulations at the orifice of the sinuses should be scraped away. A small piece of sponge saturated with undiluted carbolic acid should then be introduced into the sinus, care being taken to prevent the acid running over the skin by placing sponges around the orifice. It is well to leave the piece of sponge in the orifice of the sinus, and to insinuate past it a probe which is held in position against the bone.

A large elliptical incision is then made, embracing the orifice of the sinus, and the parts are divided in the direction indicated by the probe, the sinus being included in the dissection. When the bone is reached, the sinus should not be cut away, but the healthy bone on each side of it is exposed and chiselled through, so that the diseased portion can be removed entire ; then the diseased area should be gouged away, and the surface which is left treated as described above for a tuberculous deposit in the bone (see p. 455).

It is best to stuff the wound with cyanide gauze impregnated with iodoform and allow it to heal from the bottom, or at any rate to wait

[1] See Calvé and Gauvain : 'The treatment of tuberculous abscesses of bony origin by conservative methods.'—*Lancet*, March 5th, 1910.

until the whole surface is covered with healthy granulations and then to bring the edges of the skin together, leaving in a drainage tube for a few days. The part should be kept at rest, and when the disease affects the lower extremity, the pelvis or the spine, the patient should remain in bed or on a couch which can be wheeled out into the open air. While healing is taking place, the patient should be put under the best possible hygienic conditions.

Many cases of septic tuberculous sinuses, however, are unsuitable for this thorough treatment, and must be treated by local applications. Of these the most useful seems to be the injection of an emulsion consisting of bismuth oxychloride one part, vaseline two parts, and liquid paraffin in sufficient quantity to make the mixture about the consistency of thick cream at the body temperature. This is injected into the sinuses by means of a screw-down syringe fitted with a soft rubber catheter that will penetrate the sinus. The injection should be made immediately after the sinuses have been washed out, and enough force should be used to distend the sinus to the point of discomfort. The injection is left *in situ* and is repeated every three or four days, or at longer intervals if the discharge be only slight. In addition to this treatment, tuberculin combined with a vaccine prepared from the contaminating organism may be employed. These septic sinus cases are just the ones that derive least benefit from hygienic treatment.

Amputation.—Amputation seldom comes into question except in cases in which joint disease complicates the bone trouble. But it may have to be considered in extensive bone disease with numerous sinuses, where proper drainage cannot be established or maintained, and where at the same time the patient is suffering from phthisis, albuminuria, or amyloid disease. The indications for amputation, however, are more appropriately considered in connection with joint disease (see Vol. III.).

ACTINOMYCOSIS.

This disease is due to a fungus called the actinomyces, which is common in cattle. It may affect either the soft tissues or the bones, and it has three main seats, viz. the mouth and its neighbourhood—especially the jaws—the respiratory, and the abdominal organs.

The lower jaw is the bone most commonly attacked, and the affection generally begins as a hard tumour about the angle which slowly increases in size until suppuration occurs and an abscess forms and bursts, either into the mouth or externally. The disease goes on destroying the bone, which becomes worm-eaten, and numerous sinuses form and discharge pus containing yellow granules. If a few drops of pus be received in a watch-glass, spread out and held up to the light, these yellow grains can usually be seen distinctly. Under the microscope they appear composed of clumps of actinomyces. Sometimes, however, only a few branching

threads are found which stain well by Gram's method. The disease, when once established in the bone, may lead to metastatic deposits in the glands, or in other bones. There is usually no fever accompanying the affection, which varies very much in its virulence, some cases being quite mild, and others being almost beyond the reach of treatment.

TREATMENT.—As soon as the disease is evident, the affected bone should be cut down upon ; if only a small portion be affected, the diseased area should be excised. If it be too extensive for this, the swelling must be thoroughly opened and scraped away, until as much of the disease as possible has been removed. Iodide of potassium in large doses (gr. xxv–xxxv) should then be given three times a day and continued for a prolonged period. Very satisfactory results are obtained in this way, and an actual cure may result even in extensive cases.

CHAPTER XXV.

SYPHILITIC AND RHEUMATIC AFFECTIONS OF BONE.

SYPHILIS.

Syphilitic affections of bone may occur in the secondary and tertiary periods of acquired syphilis, and also in the inherited form. The treatment is essentially that of syphilis itself.

SECONDARY SYPHILITIC LESIONS.

Accompanying the congestive conditions of the skin in the early secondary stage of syphilis there may be bone pains which are probably due to congestion and do not leave behind any permanent lesion. But from the sixth month onwards, a definite syphilitic periostitis may occur and may lead to the formation of bony nodes. The bones most affected in this way are the skull (especially the frontal bone), the ribs, the sternum, the tibia, and the clavicle. The patient has nocturnal pains in the part, especially when warm in bed; there is tenderness and a swelling, which may be considerable, though limited to one part of the bone. In the early stages, the periosteum is thickened, and beneath its deeper layer there is an effusion of gelatinous material, in which ossification may take place if no treatment be adopted, and which is termed a syphilitic node. If, however, treatment for secondary syphilitis be employed at once, the thickening may disappear entirely.

TREATMENT.—The patient should be put on anti-syphilitic treatment (see Vol. I. p. 212), and it is well to keep the part at rest and strapped with mercurial ointment. If there be much pain, hot fomentations or lead lotion may be used; beyond this no local treatment is necessary.

TERTIARY SYPHILITIC LESIONS.

In the tertiary stage, gummata of bone and syphilitic osteitis with great thickening are met with. The gummata may occur sub-periosteally or in the medulla, and there may be either a circumscribed gummatous

mass or a diffuse infiltration of the whole bone with gummatous material. The circumscribed gummata are most frequent on the skull, where they may begin either under the periosteum, or in the diploë. They also occur frequently in the vomer, the nasal bones, the palate, the clavicle, the tibia, and the epiphyseal ends of other bones. The gummatous material spreads from the deeper layer of the periosteum into and along the Haversian canals, and leads to rarefying osteitis in its vicinity; condensation of the bone beyond takes place, so that a bone which has been the seat of syphilitic gummatous disease presents an eroded and worm-eaten surface, due to the great size of the Haversian canals, with very dense bone around. This condition is sometimes spoken of as syphilitic caries, and considerable destruction of bone may result from it.

In other cases, portions of the condensed bone may die, and thus a *syphilitic sequestrum* is formed, the characteristic of which is, that it is much denser and heavier than normal bone, because before dying it has been the seat of condensing osteitis; its surface is worm-eaten from the spread of the gummatous material along the Haversian canals. These sequestra, like those of tuberculous origin, often take a long time to separate. There is not the same stalactitic new formation of bone from the periosteum in connection with these sequestra as there is in ordinary necrosis, although, when the sequestrum is central, it may be more or less surrounded by bone.

In gummatous disease of bone there is often a good deal of pain, which is generally more intense than in the syphilitic node, of a boring character and worse at night. When gummata occur in superficial bones, they spread in the soft tissues and involve the skin, and a syphilitic ulcer forms, at the bottom of which there is bare bone, soft on the surface but very dense underneath, so that a probe cannot be pushed into it for any distance.

TREATMENT.—The treatment of gummatous disease of bone is mainly that of tertiary syphilis (see Vol. I. p. 224), but this affection is one of the forms of tertiary syphilis in which surgical intervention may materially shorten the course of the case. The operation consists in opening up the affected area, scraping away the diseased tissue, chiselling away some of the dense bone and removing a sequestrum if one be present. The whole surface of the bone thus exposed should be sponged over with undiluted carbolic acid, stuffed with iodoformed gauze, and made to heal from the bottom. At the same time anti-syphilitic treatment should be carried out. Very satisfactory results may be obtained in this way; tertiary bone syphilis is very rebellious to internal anti-syphilitic remedies alone, especially when there is an external ulcer.

HEREDITARY SYPHILITIC LESIONS.

The changes in the bones in hereditary syphilis are of great interest; one of the earliest is inflammation of the ends of the long bones, particularly those of the tibia, the humerus, the femur, and the ulna. This affection is often symmetrical, and usually affects the diaphysis in the immediate neighbourhood of the epiphyseal line, the condition often going by the name of 'osteo-chondritis' or 'syphilitic epiphysitis.' It generally occurs at a very early period of life; the bone becomes much thickened in the neighbourhood of the epiphyseal line, and a tender swelling occurs and forms a collar around the end of the bone. The condition may go on to separation of the epiphysis and destruction of the epiphyseal line.

During the first year of life, bosses of spongy bone are seen on the skull near the sutures; four bosses are often found around the anterior fontanelle, giving rise to the 'nateform' skull. At a later period there may be gummatous changes in the bone similar to those which occur in adults, and there may be destruction of the nasal or palate bones.

TREATMENT.—The treatment of hereditary syphilis of bone, is similar to that already described for the condition in general (see Vol. I. p. 226). When there is much tenderness about the epiphysis, it is well to put the limb on a splint.

RHEUMATIC PERIOSTITIS AND OSTEITIS.

Osteitis may also occur as the result of rheumatism, which affects bones as well as joints. Rheumatism chiefly gives rise to periostitis, with condensing osteitis beneath. In some cases the whole thickness of the bone may be involved.

TREATMENT.—**Medicinal.**—In the early stages the affected limb should be put on a splint, and blisters applied over the inflamed bone, or Corrigan's cautery used (see Vol. I. p. 21); 10 to 30-grain doses of iodide of potassium, or 10-grain doses of salicylate of soda should be given three times a day.

Operative.—Should the disease not yield to this treatment, the best plan is to cut down and remove as much of the thickened periosteum as possible, and at the same time to gouge away a portion of the thickened bone; in these cases it is not necessary to open up the medullary cavity.

In cases of so-called 'neuralgic osteitis,' where the pain is intense and probably due to pressure on the nerves in the condensed bone and consequent neuritis, free gouging of the affected portion is the only treatment that affords any relief. There is apparently little thickening of the bone in these cases, but marked improvement often follows the operation.

CHAPTER XXVI.

RICKETS: SCURVY-RICKETS.

RICKETS.

RICKETS may be defined as a disease of the period of growth associated with general disturbance of nutrition and marked by alterations in the bony tissues and deformities of the skeleton, as well as by various internal disorders. Children may be born with rickets (the so-called 'fœtal rickets'), but the disease generally commences during infancy, and begins to show its effects on the skeleton during and after the second year. In some cases, however, rickets first appears towards the age of puberty ('rachitis adolescentium').

ETIOLOGY.—The etiology of the disease is not clear, but from the point of prophylaxis and treatment two factors are all-important and these are widely accepted.

The effect of bad hygienic surroundings. In support of this theory it is pointed out that patients with rickets are most numerous during the early summer, the disease having been set up as the result of confinement to the house during the winter, the effects of the confinement becoming manifest towards the end of the spring or the early part of the summer. Similarly the season of the year when rickets is least prevalent is towards the end of the year, the children having had plenty of fresh air and sunshine during the summer. Rickets mainly occurs in the children of the poor, who are not only imperfectly fed, but are also closely confined to houses in which the hygienic conditions are defective.

The effect of insufficient or improper diet, especially one deficient in fat. The observations made by Bland-Sutton on the rearing of lion cubs in the Zoological Gardens prove conclusively that imperfect diet can of itself produce rickets, and there can be little doubt that bad hygienic surroundings or congenital disease render the patient more susceptible to the effects of diet.

PATHOLOGICAL CHANGES.—From the surgical point of view the main factor with which we have to deal in rickets is the osseous

deformity; this manifests itself either in enlargements about the epiphyseal lines, or in curvatures of the bones. We shall not refer to the other symptoms, but it must not be forgotten that these bony changes are only part of the general morbid condition.

Enlargement at the epiphyseal lines always occurs in rickets; curvature of the bones depends upon mechanical factors, and may or may not be present. In the thorax enlargements are found at the junctions of the costal cartilages and the ribs, forming the so-called 'rickety rosary.' When there has been obstruction to respiration, as, for example, when the child has suffered from bronchitis or broncho-pneumonia, there is generally the deformity known as 'pigeon-breast,' in which, as the result of atmospheric pressure, there is a depression at the junction of the ribs with the cartilages, so that the sternum projects and the cartilages run forward towards it. The chest may also be constricted transversely, the lower ribs being everted. The spine is not uncommonly affected; usually there is a general antero-posterior curvature affecting its whole length, but sometimes the curvature may be lateral. The pelvis may be flattened antero-posteriorly or the acetabula may be approximated, and the pelvis may be heart-shaped; it often does not develop properly and remains small throughout life, becoming a serious obstacle to child-bearing in the female.

The ribs and the bones of the extremities, especially the femur, the tibia and the radius, constantly become enlarged at their lower epiphyseal lines. If the patient bears weight on the weak bones, there is also a certain amount of bending; thus the femur becomes curved antero-posteriorly, and the tibia becomes flattened laterally and bends outwards, the common rickety deformity being bow-legs. Genu valgum is also common, and there may be an antero-posterior curvature in the tibia just above the ankle.

The changes in the bones during rickets consist essentially in excessive preparation for the formation of new bone and imperfect deposit of the hard bony structure; the epiphyseal line is thus thickened and increased in breadth. The periosteum is also thickened, and the soft tissue in the Haversian canals and lining the medullary spaces is increased in amount, while the dense bone is diminished. Hence the bones are soft and bend easily when subjected to pressure. When the rickets passes off, fresh bone is formed in this soft material, and in consequence the bone becomes much denser than normal, so that it is sometimes difficult to cut through it.

TREATMENT.—In the treatment of rickets, attention should be paid to the *feeding* of the child, and to the hygienic conditions under which it lives. Farinaceous food should be avoided during the first year of life, and during the first nine months the diet should consist entirely of milk. If the mother be unable to suckle her child, a wet nurse is the best substitute, and failing this the child should be fed on cow's milk

which, at first, is diluted with double the amount of water or barley water, and to which a little sugar of milk is added. Later on, cows' milk may be given pure.

When the child is about nine months old, some farinaceous food, such as oatmeal, may be mixed with the milk, but it should be given in small quantity; the bulk of the diet should consist of milk. Biscuits should not be administered at all until the child is nearly a year old, and then only sparingly. When the child is a year old, an egg may be given once or twice a week, and on other days a little gravy and potato, or gravy and bread. The child should not take solid animal food until towards the end of the second year.

The child should be placed under *good hygienic conditions*, should be out in the open air as much as possible, should take advantage of the sunshine to the utmost, and, if possible, should be sent to the seaside or to the country; the clothing should be woollen. The following regulations are in use at the Children's Hospital, Paddington Green, and may be taken as a type of regulations suitable for outpatient cases; they may easily be adapted for use in private practice.

FOOD.

Between 9 and 12 months.—Give cows' milk which has been brought to the boil and slightly sweetened, 1½ to 2 pints daily. Not Swiss or any form of condensed milk. Half a teaspoonful of fresh butter, or a teaspoonful of cream, may be given three or four times a day in the milk.

In addition the child may be given, not oftener than twice in the day, any plain milk pudding, or porridge made with milk, or bread and milk made as follows:—Put a slice of stale bread without crust to soak in a basin of cold water for 2 hours; then pour the water, beat up the bread, and pour over it a quarter of a pint of boiling milk. Sweeten with loaf sugar. This should be freshly made for each meal.

Feed every 3 hours by day, and only once during the night.

If diarrhœa or sickness comes on, or curds appear in the motions, give equal parts of cows' milk and lime water, or barley water. To make barley water, wash 1 teaspoonful of pearl barley, and put it in a saucepan with 1 pint of cold water. Let it come to the boil, and simmer beside the fire for half an hour. Strain and use as required. Should be prepared twice daily.

Between 12 and 18 months.—Add to the above, potato and gravy, or half an egg, once daily. After 15 months, feed every 4 hours by day, and not at all during the night.

After 18 months.—Finely minced or shredded mutton and fresh fish may be added to the above, but cows' milk should still be the principal food.

On no account keep a child at the breast after it is 9 months old. Mother's milk is useless to the child after that age, and suckling is most injurious to the mother. It is a mistake to suppose that suckling after this time prevents pregnancy.

Feed at regular times, as stated above, and not every time the child cries.

Do not give cheese, pastry, shellfish, salt or fried fish, unripe or tinned fruits, nuts, sweets, tea, wine, beer, or spirits.

CLOTHING.

Children should always wear wool next the skin.

By Night: A long flannel nightgown, fastened below the feet, and at the wrists and throat.

Let them sleep in cots by themselves—never in a draught, or between the window or fireplace and the door.

Bedclothes should be warm and light.

Keep the window open all night in warm weather.

Keep a small fire burning all night in cold weather.

By Day: (*a*) A *flannel vest*, fitting closely round the neck and loosely elsewhere. All other clothing about the chest should be loose and warm.

(*b*) A well-fitting *flannel binder* round the belly reaching from just below the hips to the lowest part of the breast bone.

(*c*) *Flannel or knitted drawers* should always be worn. They may be buttoned on to the binder, to which shoulder-straps should be added. The binder will not then slip up and down.

(*d*) In cold weather, warm stockings or woollen gaiters, reaching to the top of the legs, should be worn.

All underclothing as well as bedclothes should be well aired before and after use.

GENERAL DIRECTIONS.

Rickety children should be out of doors most of the day in fine weather.

If they cannot walk, get a perambulator in which they can lie down flat. Wrap them up well and use as a foot-warmer a strong wine bottle filled with hot water, placed in a thick stocking.

They should not be carried in arms, especially by other children.

If their backs are growing out, they should be kept always lying flat. A good plan for children with weak backs is to tie them to a small ironing board covered with several layers of house flannel, and carry them on that. Smaller children may be carried on a wicker-basket lid, padded with a folded blanket.

Children with bow-legs or knock-knees should not be allowed to stand, walk or crawl.

Keep them clean. Wash them all over night and morning with soap and warm water. Dry carefully with a soft warm towel. Then with the open hand chafe and rub the limbs from below upwards until the skin is rosy. The limbs should be rubbed one by one, the rest being covered meanwhile. The back, if weak, should also be rubbed.

Children will not take cold if they are carefully dried, especially the head and ears, and are well warmed after the bath.

The only *drugs* that seem to be of special service are cod-liver oil and phosphorus. Cod-liver oil should always be given in rickets, even when the child seems to be well nourished. The best way to administer it is in one of the practically tasteless emulsions;[1] the

[1] A good formula for an emulsion of cod liver oil is the following :—

℞	Sodii Hypophosphitis } Calcii Hypophosphitis } . . .	āā ½ gr.
	Olei Morrhuæ	♏ xxx.
	Olei Cassiæ	♏ $\frac{1}{10}$
	Glycerini	♏ vj
	Tragacanthæ	q.s.
	Aquam destillatam	ad ℥j.

dose] is a teaspoonful three or four times a day after food, and fortunately children rather like it than otherwise, so that there is usually no difficulty in getting them to take it. Phosphorus is useful in doses of a hundredth of a grain, which is best given mixed with the cod-liver oil. The compound syrup of the phosphates (Parrish's food), and syrupus ferri phosphatis are also good, but pure phosphorus is better. Iron may be of use in pale anæmic children, and the best form is probably the tinct. ferri perchlor., given in four- or five-minim doses twice or three times a day ; the syrup of the iodide of iron in half-drachm doses is also useful.

The child should be sent to the *country*, and if possible to the seaside, and, while there, *sea-baths*, or, if they cannot be obtained, baths containing sea-salt are valuable. The baths should be tepid, and friction to the limbs and abdomen should be employed after them for fifteen or twenty minutes.

The main surgical point to consider in rickets is the treatment of the deformities of the limbs which are so apt to occur. When the disease is progressing, the child should not be allowed to stand or run about, as otherwise deformity of the lower limbs and the pelvis will almost certainly result. The child should be kept in bed or lying on a mattress, and should be taken out whenever there is sunshine ; in some places the treatment of rickets consists essentially in allowing the child to lie or play on a heap of sand exposed to the full glare of the sun with only a night-dress on.

When the deformity of the limbs is only slight, the probability is that the child will outgrow it, if he can be prevented from standing and walking. Friction of the affected limbs and *manipulation* of the deformity in such a way as to unbend the curve are powerful adjuncts to success and must not be neglected. It is remarkable how quickly a curve will disappear in a young child when carefully treated in this way.

When, however, the curve is marked before the patient comes under notice, the question of *splints* or of osteotomy has to be considered. These two methods each have their place. This subject has been considered in detail in connection with the deformities produced by this disease (see Vol. I.).

SCURVY-RICKETS.

By the term ' scurvy-rickets ' is understood a condition that is really a true scurvy occurring in infantile life. The name is somewhat misleading as it seem to infer that a rickety condition is an integral part of the affection, whereas, although both scurvy and rickets are not at all infrequently found associated together, the latter disease has no causal

relation to the scurvy, which is of the same type as that found in adult life, and which, moreover, may occur in infants without any rickety change whatever.

ETIOLOGY.—Scurvy in infants, as in adults, is primarily due to a lack of fresh animal and vegetable food. That this should occur among the children in large cities seems at first sight somewhat remarkable, but the explanation is to be found in the increased prevalence of hand feeding during the last fifteen or twenty years.

Dr. Sutherland[1] and others have pointed out that, while healthy breast milk and fresh cows' milk—even when the latter has been just raised to the boiling-point and allowed to cool—are perfect foods for infants from an anti-scorbutic point of view, the same cannot be said of either the 'sterilised' milks or many of the artificial infants' foods upon the market.

With regard to the 'sterilised' milks, it may be remarked that while 'Pasteurisation'—*i.e.* subjecting the milk for 20–30 minutes to a temperature of 160° F.—does not affect its anti-scorbutic properties, true 'sterilisation,' by keeping it at or above the boiling-point for 20 minutes or more, does so in a very marked degree.

The same is true of various infants' foods prepared artificially, whether they take the form of preserved milks or starchy foods, or a mixture of the two; the treatment they have to undergo destroys their anti-scorbutic powers, and therefore they cannot be relied upon as the sole article of diet.

Even meat or meat-juice cannot be depended upon entirely to prevent scurvy; possibly it might do so were the meat quite freshly killed, but this is rarely the case, and scurvy has been known to occur where meat has formed part of the diet. Fruit and vegetables, of course, possess high anti-scorbutic properties.

It does not necessarily follow, however, that a child brought up for a long time on a diet of preserved milk or patent foods will develop scurvy; it is only safe to say that a child so brought up is not proof against the affection. There is often a history of some preceding trouble in the alimentary canal, and the disease not infrequently follows one of the specific fevers. It is far more common in the first two years of life than at any other period.

PATHOLOGICAL CHANGES.—The chief morbid changes that concern us from the point of view of treatment are those occurring in the bones.

Whereas in adults spongy, bleeding gums are the most frequent signs of scurvy, in infants the disease mainly manifests its presence by

[1] Dr. G. A. Sutherland, *Clinical Journal*, 1897 The reader desirous of further information on this subject may with advantage consult this paper, from which many of the above points are taken.

subperiosteal hæmorrhages in the long bones. At some point along the course of the bone a firm swelling develops, which gradually increases in extent and may spread along the entire length of the shaft. This swelling consists of blood extravasated beneath the periosteum, and also, to a lesser extent, among the deeper muscles. As a rule, fluctuation is difficult to make out. The femur is most frequently affected, and the bones of the lower extremities are usually attacked before those of the upper.

Fractures, either spontaneous or following slight violence, are apt to occur in bones thus affected, and union does not take place until the disease has become arrested. In cases of scurvy, pure and simple, these fractures are commonest in the shafts of the long bones; while in the cases of scurvy associated with rickets, separation of one or both epiphyses of the bone affected is more likely to be met with.

Spongy and bleeding gums are not very noticeable in these cases. If the child has no teeth, there is but little alteration in the gums. The older the child is, however, the more prominent this symptom becomes, while the lesions in the long bones are proportionately less severe.

SYMPTOMS.—A child affected with scurvy becomes listless and anæmic, sallow in colour, and irritable if disturbed. There may be the characteristic bleeding and spongy gums or hæmorrhages from the bowel or kidneys, or into the subcutaneous tissues. Hæmaturia is an important symptom, and when this symptom occurs in infants the possibility of scurvy-rickets being the cause should never be forgotten; the kidney has been vainly explored for stone under these circumstances. Later on there are extravasations of blood beneath the periosteum of various bones, chiefly those of the extremities, resulting in inability to use the affected limbs and intense pain when they are handled. If the case be left untreated, the hæmorrhages increase, and the child dies from exhaustion or some intercurrent affection.

Quite trivial cases of scurvy occur in which the only symptom to attract attention is tenderness of the lower extremities, the child crying whenever he is handled or washed. Occasionally there may be slight reddening around any teeth that are present, but the tenderness may be the only symptom. That these patients are really suffering from scurvy is shown by the rapidity with which the symptoms yield to treatment; they disappear completely in two or three days.

TREATMENT.—**Prophylaxis.**—No child, brought up upon a suitable diet, can develop this condition. There is no known case of the disease among infants brought up on breast-milk during the ordinary lactation period; after that time it is said that the milk undergoes changes which rob it to a certain extent of its anti-scorbutic powers.

Should the breast-milk fail, its place must be taken by pure fresh cows' milk, and it is most important to remember that no artificial food or milk prepared otherwise than by scalding, boiling, or Pasteurising, should be given during this period except as a temporary measure because the child is unable to digest fresh milk. Even then it will be well to administer orange-, grape- or lemon-juice in teaspoonful doses twice a day.

After the age of nine months, vegetables and fruit should be added to the diet, which will still be mainly milk. The subjoined table of instructions, issued to mothers at the Paddington Green Children's Hospital, may be made to serve as a model either for private or hospital practice.

HOW TO BRING UP BABIES.

FEEDING.

I. **If the Mother is perfectly healthy and has plenty of Milk,** breast milk alone should be given until the infant is 8 months old.

Suckle every 2 hours by day, and twice by night, until the child is 3 months old ; then suckle every 3 hours by day, and once only by night. Too frequent suckling makes the milk poor and does not satisfy the baby.

The mother's nipples should be bathed with warm water both before and after suckling. Also wash the inside of the child's mouth with a small piece of clean linen and warm water after taking the breast. This will prevent 'Thrush.'

Begin to wean at 8 months, and wean completely at 9 months.

Between the eighth and ninth months let the child have three times a day a mixture of two parts of cows' milk and one part of barley water, sweetened with one lump of sugar or one-third of a teaspoonful of malt extract to each bottle. The cows' milk should be just brought to the boil.

The barley water is made as follows : Wash one tablespoonful of pearl barley, and put it in a saucepan with one pint of cold water. Let it come to the boil, and then simmer beside the fire for half an hour. Strain and use as required. Should be prepared twice daily.

II. **If the Mother has only a little Milk,** the child should still have it. Give also one part cows' milk and two parts barley water, made and sweetened as above.

There is no harm in mixing the milks. It is better to get ordinary dairy milk than milk from one cow.

Should diarrhœa or vomiting come on, give equal parts of milk, lime water and barley water.

III. **If for any reason the Breast cannot be given,** feed as follows :—

Up to 3 months.—One part of cows' milk and two parts of barley water—prepared and sweetened as above—every 2 hours by day and twice by night. Give one-sixth of a pint of the mixture at each feed, and add a little more milk each week until—

Between 3 and 6 months.—Equal parts of cows' milk and then barley water may be given, 1½ to 2 pints a day. One-third of a teaspoonful of fresh butter, or a

teaspoonful of cream may be given twice daily in the milk. Feed every 3 hours by day, and once during the night.

Between 6 and 9 months.—Two parts of cows' milk to one part of barley water. Then add gradually more milk and less barley water until at 9 months the child is taking plain milk.

On no account give any infants' food, condensed milk, bread, biscuits, or tops and bottoms until the child is 9 months old, except by doctor's orders.

If the cows' milk does not seem to agree, consult a doctor, not the chemist.

Never give babies at any age sweets, pastry, fruits, cheese, salt meat, salt or fried fish, tea, wine, beer, or spirits.

Between 9 and 12 months.—Besides 1 pint or 1½ pints of cows' milk, the child may be given, not oftener than twice in the day, any plain milk pudding, or porridge made with milk, or bread and milk made as follows: Put a slice of stale bread without crust to soak in a basin of cold water for 2 hours; then pour off the water, beat up the bread, and pour over it a quarter of a pint of boiling milk; sweeten with loaf sugar. This should be freshly made for each meal.

Between 12 and 18 months.—Add to the above, potato and gravy, or half an egg once in a day. After 15 months, feed every 4 hours by day and not at all during the night.

After 18 months.—Finely minced or shredded mutton and fresh fish may be added to the above, but cows' milk should still be the principal food.

Feed only at meal times, never between meals, 'Just to keep the baby quiet.' Babies often cry not because they are hungry, but because they are thirsty. A little pure water or barley water, flavoured with orange-juice, will satisfy them.

The bottle should have a nipple, but no tube. Scald it out both before and after use, and cleanse with a brush.

Prepare at a time only enough milk for one meal. Never give what is left over in the bottle for the next meal. Taste the milk before feeding, and be sure it is not sour or smoked.

GENERAL DIRECTIONS.

I.—*Sleeping.*—The child should sleep in a cot or basket alone. Many babies are overlaid every year from sleeping with their parents.

If babies kick off the bedclothes, put them in long flannel nightgowns, fastened below the feet and at the wrists and throat. They must not lie between window and door, or fireplace and door. Keep the window open all night in hot weather. Keep a small fire burning all night in cold weather.

II.—*Clothing.*—Should be loose round the chest and close round the belly. Do not let them go about with nothing on below the armpits, but petticoats. A flannel binder round the belly and warm drawers should always be worn.

III.—*Washing.*—Wash them all over with soap and warm water night and morning. Dirty children are always delicate. They will not take cold if carefully dried, especially about the head and ears, after the bath. It is a good plan to put them to bed between the blankets for half an hour after the morning bath.

IV.—*Fresh Air and Sunlight* are nearly as important as food to children. Take them out every day in fine weather.

Curative.—*General.*—When the disease has become established, the effect of proper treatment is generally very marked. All artificial foods should be stopped and the child put upon a diet of fresh scalded cows' milk, properly diluted according to the age of the patient.

With this many authorities recommend the administration of fresh meat juice.

Modification of the milk can often be avoided by the addition of sodium citrate. The milk is given scalded and undiluted, with a grain of citrate of soda added to each ounce. For example, when a five-ounce feed of milk is ordered, the parent is given a solution of citrate of soda containing five grains to the drachm, with instructions to add one teaspoonful to each feed.

More important than either of these, however, is the addition of fresh fruit and vegetables to the dietary. The most useful fruits are oranges, lemons, and grapes; the vegetables may be dressed in the ordinary manner or given in soups.

The drug treatment does not call for much notice. There is no specific drug for the disease, and all that is necessary is to treat on ordinary medical lines any complications that may arise. The child must be placed under the best possible hygienic conditions, and rickets, if present, must receive appropriate treatment (see p. 464).

Local.—The treatment of the affected bones is of importance. In severe cases absolute rest in bed must be insisted upon, both on account of the liability to fracture, and because the child is apt to suffer from severe attacks of syncope. For the first of these reasons also, the greatest care must be taken in handling the child while performing the ordinary nursing functions.

The limb affected should be put upon a suitable splint, and, should a fracture occur, suitable apparatus will be required. Sandbags, however, are often better for fixing the limb than splints, as the tenderness is extreme. A sheet or towel is placed over the limb and sandbags of suitable size are rolled up in each end. As the disease subsides, splints may be applied, and union will occur.

The subperiosteal extravasation usually becomes absorbed as the child improves under treatment; rest will facilitate this. Should there be pyrexia and much tenderness, it may be impossible to be sure whether suppuration is going on beneath the periosteum. The question can be cleared up by the use of a large aspirating needle. Should the extravasation be excessive, however, absorption will be very slow, and under these circumstances, provided that the child be otherwise improving, and that absorption has come to a standstill, it may be advisable to cut down upon the swelling, incise the periosteum, and turn out all the clot. The clots are removed partly by the finger, partly by gentle irrigation with normal saline solution, and partly by compressing the limb. The wound is then sewn up without a drainage tube, and a large mass of wool is bandaged on firmly outside the dressing so as to exert compression and prevent re-accumulation of blood. By treating cases in this

way absorption will be hastened, the adhesions between muscles lessened, and the course of the case shortened. The operation is only permissible under the strictest antiseptic precautions; septic infection would entail widespread necrosis at the very least, as the periosteum in these bad cases is separated from the bone throughout the entire diaphysis.

CHAPTER XXVII.

DISORDERS OF OSSIFICATION.

OSTEOMALACIA.

This is a fairly well defined disease which seems to bear some relationship to ovarian activity. It is commonest in pregnant women, especially those in whom the pregnancies have been rapid and repeated. It is rare in men and children. It has been recently observed that there is an increased output of lime salts during normal menstruation, and further it has been observed by Hanau that osteophytes and osteoid tissue occur in the cranial bones of 25–30 per cent. of puerperal women, indicating that there is some relationship between this disease and the ovarian functions. The disease is endemic in the Rhine Valley, Flanders, Westphalia, and Northern Italy, but cases occur occasionally in other countries.

The chief manifestation of the disease is softening of the bones, which affects the whole skeleton and leads to great deformity. There is rarefaction of the bones with loss of calcareous salts; the bones at first are slightly enlarged and the medullary cavity is increased in size and contains red marrow, while the compact tissue becomes much thinned and is often perforated like a sieve. The bones are very liable to fracture, and, short of that, they bend in a most extraordinary manner. The disease usually proves fatal in about two years from its commencement from cachexia, asphyxia or some acute affection of the respiratory organs.

TREATMENT.—The patient should be put under the best hygienic conditions. Among drugs, phosphorus, phosphoric acid, and more especially phosphate of zinc (a twentieth or a twenty-fifth of a grain in pill three times a day) are advocated, but they do not seem to produce any particular effect. If the patient be pregnant it is well to produce abortion. Improvement has been recently reported from the use of bone marrow in tabloids containing 1½ grains. Two or more tabloids may be given three times daily. Some observers report good results from oöphorectomy.

OSTEITIS FIBROSA.

Conversion of the bone marrow into fibrous tissue occurs in this rare affection ; in some of the cases the entire medullary cavity is occupied by dense fibrous material. The condition is usually confined to one or two bones ; cysts are not infrequently found.

TREATMENT.—Removal of the fibrous tissue is called for. The periosteum, which is usually normal, is incised over the affected area, the extent of which is usually easily determined by a radiogram ; a gutter is then cut in the thinned compact tissue and the whole of the fibrous tissue is carefully scraped away. If cysts occur they should be dealt with as described below. The periosteum is then sutured and the wound closed. Care must be taken to protect the part from injury, until radiographic examination shows that repair has taken place.

OSTEITIS DEFORMANS.

This disease usually occurs after the age of 45 and affects males more often than females. It begins insidiously with slight but increasing aching pain in the affected bones. It generally starts in the tibia, spreads to the femur, and gradually affects the chief bones of the skeleton. In the early stages there is a diffuse fibrous osteo-myelitis with the formation of multiple small cysts. Lime salts are ultimately deposited in the altered bone. These two processes go on side by side, the bones becoming bent and losing the normal arrangement of their trabeculæ, but, owing to the deposition of lime salts, becoming thickened and heavy, so that the femur and tibia are bowed forward ; the spinal column becomes bent, rigid and thickened, there is loss of height, the chin is protruded and the chest sunk on the pelvis. The disease usually progresses steadily, the muscles become weak so that walking is difficult, and the patient ultimately dies of exhaustion, though in some cases bone tumours may occur and death not infrequently results from them.

There is no known treatment that is likely to do any good in this affection.

BONE CYSTS.

Apart from cysts occurring in tumours in bone, such as myeloid sarcoma, chondroma and myxoma, simple cysts are met with in bone which are not associated with new growth. These occur in the medulla and cause expansion of the bone. Those which we have met with have been at the upper end of the humerus, but they also occur in other bones, especially the femur and tibia. The wall of the cyst is generally lined with a thin layer of connective tissue, and the medulla in the neighbourhood contains fibrous material apparently of inflammatory origin ; the periosteum is not thickened. Apparently it is a chronic fibrous

osteomyelitis with cystic formation. The great majority of cases begin before twenty years of age, and the bone increases in size slowly as compared with one that is the seat of a malignant tumour ; fracture of the affected bone is not infrequent.

The diagnosis is made by the slow growth, the age of the patient, the X-ray appearances of a cavity in the bone, and by exploration.

TREATMENT.—In the cases in which the cavity does not involve much of the shaft, the cyst should be opened and curetted freely. Severe hæmorrhage may occur as a result of this, for which it may be necessary to use Horsley's wax and pack the cavity firmly. When, however, the hæmorrhage is not severe, the periosteum may be sutured after the curetting, and the cavity allowed to fill with blood which, in time, becomes replaced by calcified tissue.

In severe cases so much of the bone may be involved, and the walls of the cyst may be so thin, that even curetting may practically amount to an excision of a portion of the shaft of the bone. If this be the case, the periosteum should be carefully stripped off the cyst throughout its whole extent, and then the whole of the thin wall of the latter removed. The shortening which would otherwise follow must be prevented by the insertion of some form of internal splint to keep the ends of the bone apart, such as a bone-graft (see p. 309) or a sterile rod of ivory, or vulcanite, interposed between the remains of the shaft and the articular end ; the reflected periosteum is sutured around the graft and the wound closed. The latter method, avoiding as it does the transplanting of tissue from one patient to another or the loss of a healthy bone from the same individual, seems the best way of dealing with these cases; a very successful case of the kind has been reported by Mr. Lett.[1]

FRAGILITAS OSSIUM.

This is a rare congenital condition in which the bones are imperfectly ossified and so brittle that they give way even during intra-uterine life, the patient sometimes being born with multiple fractures. Some of these cases exhibit signs of congenital syphilis.

TREATMENT.—This resolves itself into the protection of the child from injury and the treatment of any constitutional affection. The fractures usually unite, but, owing to their multiplicity, splinting is difficult and vicious union is common. Some cases have survived, although most of them die from inanition ; those that survive are usually stunted. The condition is important from a medico-legal aspect, as prosecutions have been instituted against parents on account of repeated fractures.

A similar condition occurs in extreme old age, which is due to simple *atrophy* of the bone.

[1] *Lancet*, Oct. 22nd, 1910.

ACROMEGALY.

In this condition the overgrowth of bone commences generally between the ages of fifteen and thirty-five, and consists in enlargement of the hands and forearms, the feet, the jaw, and sometimes other bones. It is accompanied by mental slowness and often imbecility, wasting of muscles, exaggeration or loss of reflexes, and increasing weakness. The bones are more porous than usual. In a large number of cases the pituitary body has been found to be greatly enlarged. The enlargement of this structure leads to expansion of the sella turcica in which it lies, and this can generally be seen in a radiogram.

TREATMENT.—Good results have been reported to have followed removal of the enlarged pituitary body, but the operation is so severe and the success following it is so uncertain, that the whole matter must be regarded as in a stage at which it is not wise to pronounce a definite opinion.

We shall not describe conditions such as Achondroplasia or Gigantism as no treatment is likely to be of any benefit in them.

CHAPTER XXVIII.

TUMOURS OF BONE.

TUMOURS in bones occur as primary growths, as secondary deposits in connection with tumours in distant parts, or as extensions of tumours commencing in the soft parts in the neighbourhood.

The primary tumours of bone are chiefly exostoses, chondromata and sarcomata. Secondary tumours are sarcomata or carcinomata, arising either by metastasis or by extension from neighbouring parts. Hydatid cysts also occur.

EXOSTOSES.

Exostoses occur in two forms, the ivory sessile variety found chiefly on the skull, and the spongy pedunculated form which occurs in the neighbourhood of the epiphyseal lines. The spongy exostoses may be multiple, and may interfere with the movements of the joints or muscles in their neighbourhood. The ivory exostoses usually occur on the bones of the skull, and seldom attain any great size. As a rule they do not cause any trouble beyond possibly a little deformity. They are sessile and very dense.

TREATMENT.—When a patient has an exostosis which causes him inconvenience, there should be no hesitation in removing it, unless it be in some inaccessible region. The removal of a *spongy exostosis* is comparatively easy because ossification generally commences very early at the point of junction of the exostosis with the bone, and growth only proceeds in connection with the layer of cartilage which covers its surface; hence an exostosis of large size may have a narrow neck. An incision is made down to the tumour, the neck is cleared and chiselled off or clipped through with bone forceps, after which the growth is shelled out of its capsule. The operation must be performed strictly aseptically. Before the antiseptic period, even this slight damage to the bone was often followed by severe sepsis, and many patients died of pyæmia. At the present time, however, these operations are perfectly simple and safe.

In the case of the *ivory exostoses* a widespread fissured fracture of the skull may be produced in trying to chisel them away; therefore, unless special circumstances, such as pressure on nerves or important structures such as the eye, or the external auditory meatus, call for their removal, they are better left alone. For the method of removing them when they are seated on the skull see Vol. III.

CHONDROMATA.

The chondromata are commonly met with in connection with the phalanges and metatarsal or metacarpal bones. They are generally multiple, and grow either from the outside or in the interior of the bone. They are usually benign.

TREATMENT.—As a rule it is sufficient to cut down and remove the projecting portion and then gouge away any deposits of cartilage which may be present in the neighbourhood. If the tumour is growing in the interior of the bone, the outer layers of the bone must be chiselled through, and then the soft chondromatous material scooped out. Sometimes recurrence takes place after these operations, but they can be repeated without risk if the operation be done aseptically. When, however, there is any suspicion of malignancy, it is better to amputate if possible.

SARCOMATA.

The sarcomata of bone may be of various kinds. Perhaps the most common is the *osteo-sarcoma* or *periosteal sarcoma*, beginning in the periosteum and spreading along it. These tumours usually show imperfect ossification, and the secondary tumours to which they give rise are similar; they are very malignant, and the chances of curing the patient are small. *Spindle-celled sarcoma* is also common in connection with the periosteum of bones. *Round-celled sarcoma* is often found in the interior of the bone, its most common seat being the head of the humerus. It is very malignant.

Treatment.—Amputation wide of the disease affords the only chance of success in *osteo-sarcoma* and *spindle-celled sarcoma*, and no attempt should be made to save any portion of the affected bone; the operation must be performed through or above the neighbouring joint. Metastatic deposits occur early, and usually affect the lungs. In the endosteal sarcomata, even when of the round-celled variety, it is a general rule that the tumours which commence in the interior of the bone do not spread widely throughout it, so that if the lower end of a bone, such as the femur be affected, amputation below the trochanters may be done in preference to enucleation of the entire bone; the medulla, however, must be examined carefully to see that no disease has spread up it. If the growth be in its most common situation, at the head of the humerus, the amputation must be through the shoulder-joint, taking

care to remove all the ligaments and muscles around, or Berger's amputation (see p. 525) may be necessary if the disease has spread on to the ligaments and scapula.

MYELOID SARCOMATA practically only occur in connection with bone. They are chiefly met with in the lower end of the femur, the lower end of the tibia, and the lower jaw. They are the least malignant of all the sarcomata; in fact it is an open question whether they ever give rise to secondary deposits, and therefore the treatment need not be so drastic as that of the other forms.

Treatment.—It is now recognised that in many cases these growths may be scooped out of the bone without recurrence taking place, but in doing this it is necessary to be quite sure that all the soft tissue has been removed. Sometimes this is not feasible when the myeloid sarcoma has been in existence for some time, because, after the growth has been scooped out, no bone is left behind. In these cases it is well to amputate, but the operation need only be done through the bone at a short distance above the tumour. A tourniquet should be put on the limb to minimise the bleeding during the scooping out of the tumour, otherwise this may be excessive. If the bleeding ceases readily at the end of the operation, the soft parts may be united without a drainage tube. When the oozing is severe, it may be necessary to fill the cavity with very hot water and elevate it in order to check the bleeding, and in these cases a drainage tube will be required for the first forty-eight hours.

SECONDARY TUMOURS.

As a rule there is no object in operating upon the secondary malignant tumours of bones, such as epitheliomata or carcinomata, for their occurrence implies such general infection of the body that it is not worth while subjecting the patient to the risk of operation. Therefore, the treatment in these cases consists in applying proper apparatus, with the view of steadying the part should fracture have occurred, and of relieving the pain, or of trying such expedients as radium, Coley's fluid, X-rays, etc.

DIVISION III.

AMPUTATIONS.

CHAPTER XXIX.

AMPUTATIONS: GENERAL CONSIDERATIONS.

THE PRESENT POSITION OF AMPUTATION IN SURGERY.

In reviewing the position that amputation occupies in surgery at the present time, one cannot fail to be struck by the great changes that have taken place in recent years—changes so profound that it is no exaggeration to say that our views on amputation have been quite revolutionised.

Greater Deliberation of Present-day Operating.—The first striking change is the entire disappearance of those brilliant operations in which the limb was removed (usually by transfixion or by the circular method) in a few seconds. Thanks largely to the introduction of anæsthetics, their place has been taken by more careful, deliberate and elaborately planned operations, in which the chief consideration is not the length of time taken in removing the limb, but the proper formation of a sound stump provided with a sufficient covering of soft parts, and as long as the condition of the tissues will allow. Rapidity of operating is valuable as it minimises shock, but accuracy must not be sacrificed to brilliancy.

Infrequency of Amputations.—A second and almost equally striking point is the comparative infrequency with which amputation is now performed. It was formerly the custom to submit to amputation many cases in which the question does not now even occur to the surgeon, for, thanks to the introduction of asepsis, conservative surgery is carried to a degree formerly undreamt of. In compound fracture, for example, amputation was formerly the rule, but now it is possible to save the limb in

a large proportion of the cases, either by employing conservative methods, or, at the worst, by means of partial amputations which were out of the question at a time when the risk of sepsis was a constant menace.

The Increasing Favour of Irregular Flaps.—A third and very noticeable fact is that nowadays amputations are rarely carried out on the hard-and-fast lines formerly laid down for the surgeon's guidance. The use of irregular flaps and irregular amputations is coming more and more into vogue. In fact, the particular method of amputation adopted in any given case now depends, not upon the surgeon's predilection for any one form of incision or kind of flap, but upon the actual conditions of the part. Thus, in amputating for injury, the main idea present in the surgeon's mind is how to insure the patient a stump that shall be as useful as possible, and therefore he will often shape his flaps in an irregular manner, so as to obtain a longer or more useful stump than would be got by means of any orthodox amputation. To describe the various irregular amputations that are constantly being done would be quite impossible, but it is safe to say that many of the set amputations found in text-books are only performed upon the cadaver. The introduction of antiseptics has greatly assisted in this direction. Through their agency the chances of inflammation in the stump have been greatly diminished, the risk of sloughing of partially-injured flaps has been reduced to a minimum, and the danger of secondary hæmorrhage has practically disappeared. Thanks to asepsis, we are now enabled to fashion flaps, even from tissues that have been bruised by the injury, provided that their vitality has not been seriously impaired.

Predominance of the Skin-flap.—Another noticeable feature in present-day methods is the increasingly frequent use of skin-flaps, and the diminution in the amount of muscle employed to cover the bone. This is accounted for by the fact that inflammation is absent from aseptic wounds, and that, therefore, the sloughing of the skin-flaps, which led to their rejection in former times, is not likely to occur.

THE ESSENTIALS OF A GOOD AMPUTATION.

There are three essentials in all cases of amputation. In the first place, the bone must be covered satisfactorily; in the second, the diseased or injured parts must be removed completely; and in the third place, the stump left must be as useful as possible, rounded and supple, but firm enough to bear considerable pressure without pain.

Position of the Cicatrix.—When the end of the stump is required to support pressure, the cicatrix must not be in such a position as will expose it to pressure from the divided end of the bone; it is also most important that the flap shall not be adherent to the bone, and that the cicatrix shall be painless. These requirements can generally be arranged for with a little care. In amputating in the lower extremity, the incision

should be planned so that the line of union of the flaps lies behind the bone, because the muscles on the posterior aspect of the limb are stronger and contract more powerfully than those on the front. Were the flaps to meet upon the anterior aspect of the limb, this contraction would cause the scar to be pulled directly over the end of the bone to which it would then become adherent.

Avoidance of Adherent Flaps.—Adhesion of the flaps to the bone is best avoided by making sure that the entire wound heals by first intention. If this be the case, and the flaps be of sufficient length, they will not adhere to the bone, for firm adhesions between these structures are usually the result of suppuration and granulation of the flaps.

Painless Scar.—If the large nerves be divided at a higher level than the other structures in the flap, they do not become pressed upon by the cicatrix or adherent to the bone. This is a point of great importance, because, should the nerves become involved in the scar, bulbous enlargement will occur, neuritis will be set up, and the patient will suffer from intense neuralgic pain, aggravated by the slightest pressure. The ends of the tendons should also be cut short unless there be some special reason for retaining their action upon the stump. If they become adherent to the end of the bones or the flaps, they may materially interfere with the patient's comfort and his ability to bear pressure upon the stump.

METHODS OF AMPUTATING.

There are certain classical methods of amputating, and, in addition, many irregular methods adapted to special cases.

THE CIRCULAR METHOD.

This was the earliest form of amputation known, and for a long time was in general use. It was subsequently elaborated into what is known as the modified circular method, which is still frequently adopted in the

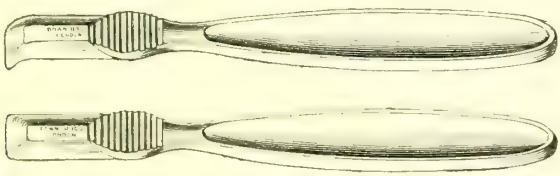

Fig. 214.—Rugines or Periosteum Detachers. These are of different shapes according to the purposes for which they are used.

upper extremity. In the circular method, the skin and subcutaneous tissues are first divided by one sweep of the knife drawn circularly round the limb. The divided structures are then retracted for two inches or more, and a series of circular sweeps of the knife is made through the muscles, commencing at the level of the edge of the retracted skin. As

each sweep is made, the cut muscle retracts, and the succeeding sweep is made close up against its retracted upper edge. The last sweep of the

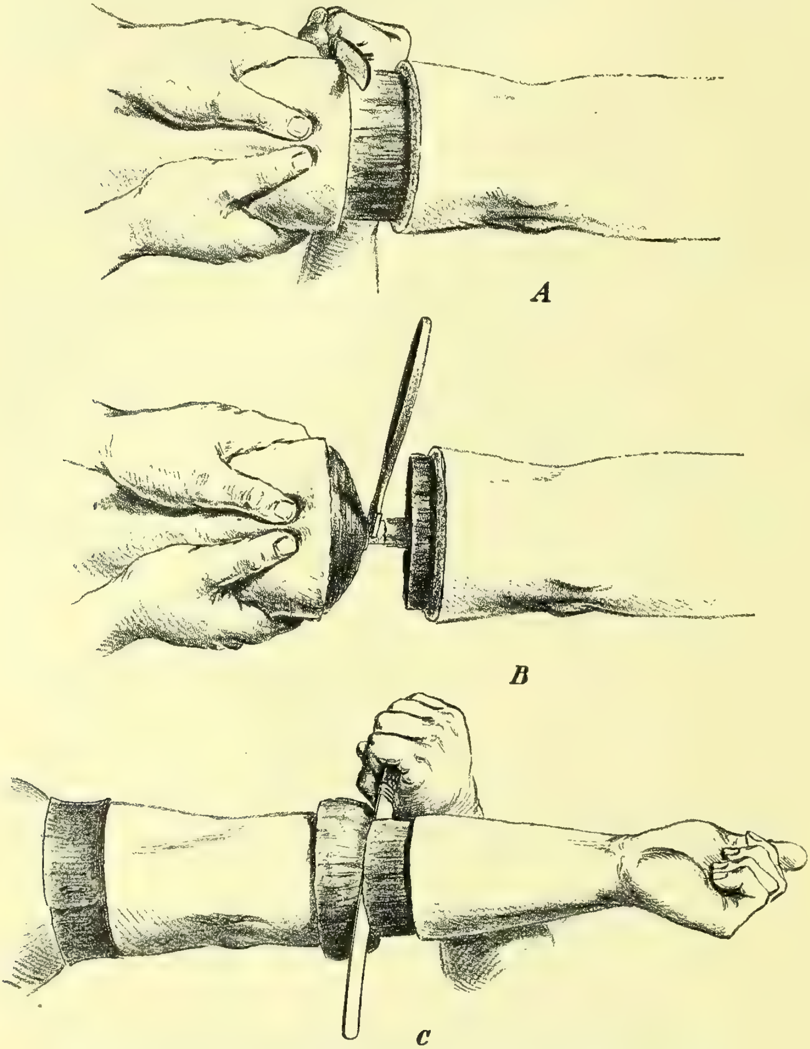

FIG. 215.—CIRCULAR METHOD OF AMPUTATION. In *A* the skin has been divided by a circular sweep of the knife, and is being retracted by an assistant prior to the circular division of the muscles which is seen accomplished in *B*, where the periosteum, after being divided circularly, is being stripped up by a rugine. *C* shows another but slower method, in which the cuff of skin is dissected up and turned back before the circular incision is carried through the muscles.

knife is carried right down through the periosteum, which is thus divided circularly on the same level as the muscles. As the latter are retracted still further, the periosteum should be stripped up by a rugine (see Fig. 214) along with the muscular mass. The muscles should never be first

stripped off the periosteum, and the latter then separated from the bone. Both should be pushed up off the bone together or the blood-supply of the periosteum will be damaged. The whole of the soft structures are then retracted for a little distance, and the bone is cleared and sawn at a point well above the division of the muscles (see Fig. 214). The result is that when the structures are allowed to fall into position, the stump presents somewhat the appearance of a hollow cone, at the apex of which lies the divided end of the bone, the base being formed by the circular cuff of skin.

The chief merit of this method is its rapidity, but it possesses another

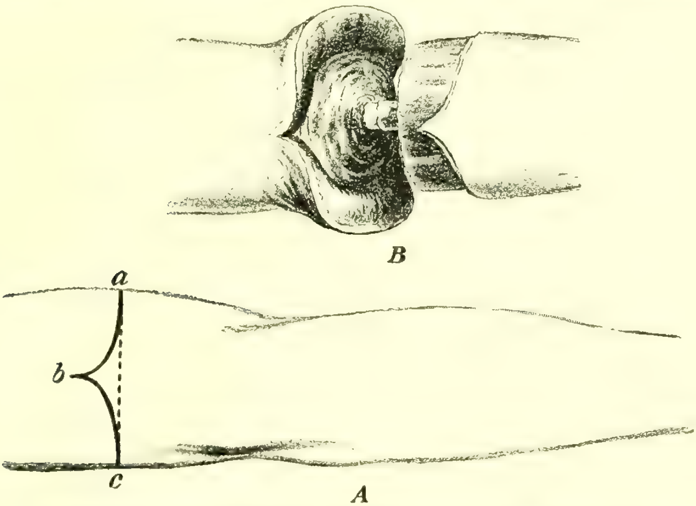

Fig. 216.—The Modified Circular Method of Amputation. The dotted line *ac* in *A* is the ordinary incision in the circular method, while the thick line *abc* shows the modified circular incision. The skin flaps are shown in *B*, as well as the circular division of the muscles.

merit that is of great importance in some cases, viz., that it involves the least sacrifice of the soft parts of any amputation, and therefore that it permits the limb to be removed nearest to the damaged part if the damage affect the circumference of the limb equally. On the other hand, it possesses many objections. In the first place, it is difficult to perform in a conical limb, for the retraction of the different layers is not easily effected; and if the cuff of skin has to be dissected up and turned back, the operation ceases to be a rapid one. The retraction of the soft parts also may be much hindered by matting together of the tissues as a result of old inflammation. The cicatrix must necessarily lie over the end of the bone, and is generally puckered. The amputation, therefore, can never be used for cases in which pressure has to be borne upon the end of the stump. Moreover, unless the operation be done with considerable care, the skin covering is by no means abundant, and there is considerable tension upon the edges.

THE MODIFIED CIRCULAR METHOD.

The true circular method has been almost entirely abandoned in favour of what is termed the modified circular method, in which two

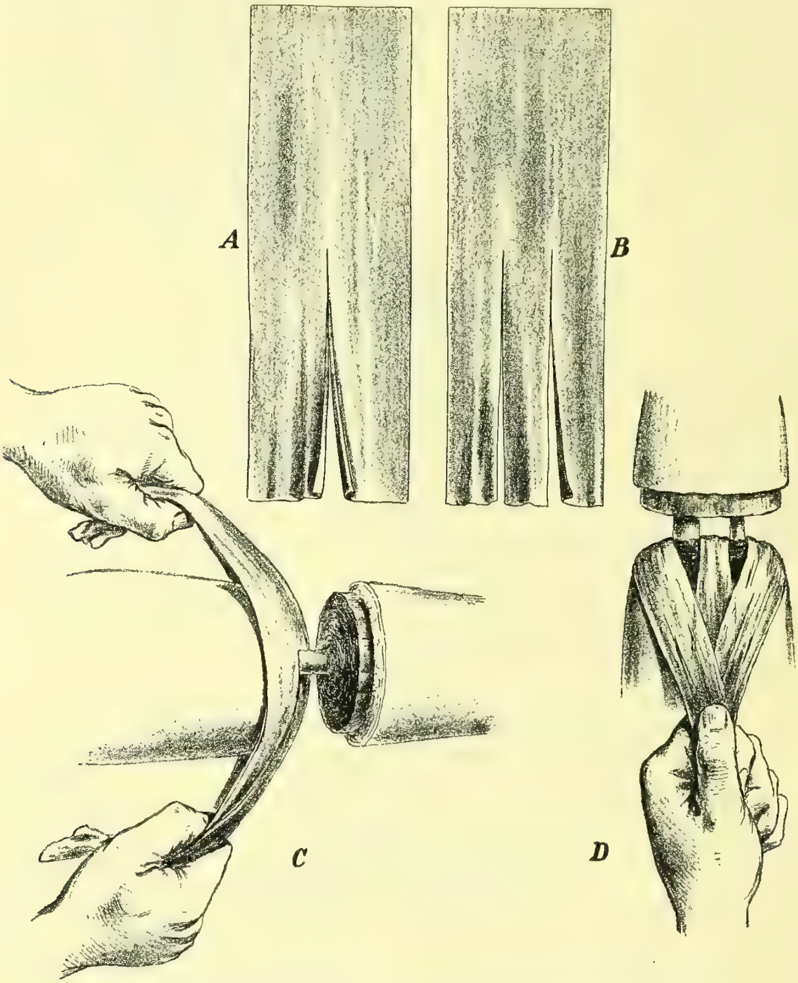

FIG. 217.—BANDAGE RETRACTORS FOR AMPUTATIONS. *A* and *B* show two-tailed and three-tailed bandage retractors respectively. *C* shows the method of using the two-tailed retractor to protect the soft parts, while *D* shows the three-tailed retractor used for a similar purpose.

equal flaps of skin and subcutaneous tissue are cut,[1] just slightly longer than the cuff of skin fashioned in the circular method. The division of

[1] In the case of a forearm of ordinary size, the lower limit of the flaps will be about 1½ inch below the seat of the circular division of the muscles, and this again about 1½ inch below the point of section of the bone. In the upper arm each of these measurements will be increased to 2½ inches or more.

the muscles is greatly facilitated by this method of dividing the skin, and there is no difficulty in retracting the flaps. The muscles are divided by a series of circular sweeps of the knife as for the ordinary circular operation (see Fig. 216).

Retractors.—In the circular method the retraction of the muscles is often difficult, especially in a conical limb like the thigh, and there is some danger of wounding the assistant's fingers unless mechanical means of retracting the muscles be employed. A simple retractor can be extemporised from a broad piece of sterilised bandage or muslin split longitudinally down the centre for about half its length (see Fig. 217, *A*); the two tails thus formed are applied one on either side of the bone, and an assistant retracts the soft parts by seizing the two tails with one hand and the undivided end with the other (see Fig. 217, *C*). A similar effect can be produced by laying a piece of ordinary bandage on either side of the bone, crossing the ends of the two pieces and making traction upon them. When the limb has two parallel bones the retractor may conveniently take the form shown in Fig. 217, *B*; the muslin is split into three tails, the centre one being passed between the two bones, and the lateral ones outside them.

Cases Suitable for this Method.—The modified circular method is very useful in the upper extremity. Here the length of limb that can be preserved is very important, and it is no drawback to have the cicatrix lying directly over the ends of the bone; on the contrary, this may be actually desirable. In the lower extremity it is generally inadmissible to have the cicatrix over the end of the bone, except possibly in cases of amputation through the shaft of the femur where the pressure of an artificial limb is borne upon the pelvis and not on the end of the stump; in all amputations below this the method is generally modified by making one of the flaps longer than the other. As a rule the anterior flap is longer than the posterior, so that the cicatrix lies well behind the end of the bone.

THE 'MIXED FLAP' METHOD.

In the so-called 'mixed flap' method the circular division of the muscles is also abandoned. Two flaps are made, generally of unequal length, the commonest being a long anterior and a short posterior flap. The first two inches or so of the longer flap should consist merely of skin, subcutaneous tissue and deep fascia; but as the flap is dissected up above this point, the knife is made to take up a steadily increasing thickness of muscle, so that, when the point is reached at which it is proposed to divide the bone, the muscle is divided right down to that structure (see Fig. 218). In the shorter flap it is well to take up only skin, subcutaneous tissue, and deep fascia for the first two inches or more, and then to cut through the muscles more or less directly down to the bone. There is no need to take up the muscle gradually as in the

other flap, on account of the greater contractility of the muscles on the posterior aspect of the limb. When the flaps have been retracted, the bone is divided at a slightly higher level than the base of the flaps. Here again, as in the circular method, a collar of periosteum may be raised in a similar manner and with a similar object. No retractors are required to keep the muscles out of the way of the saw in this form of amputation. The flaps are folded back and the soft parts are then well out of the way of harm.

The advantage of making the lower end of the flaps consist of skin

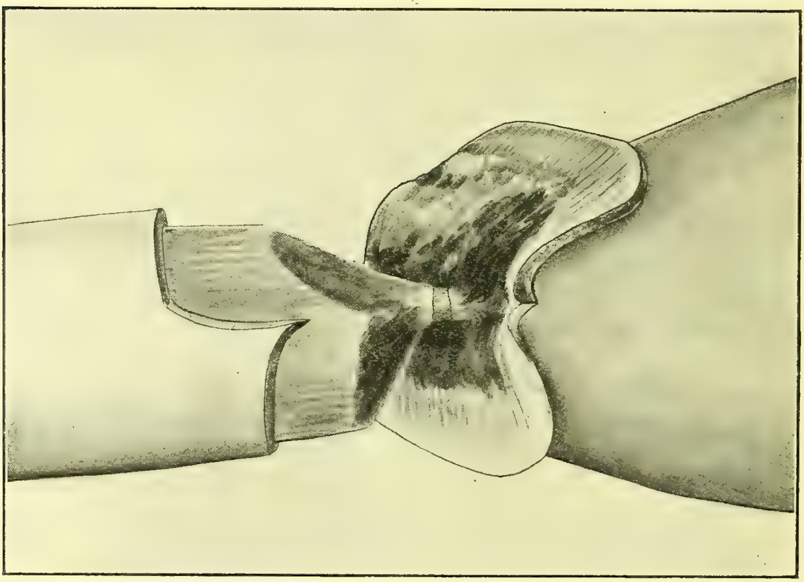

FIG. 218.—AMPUTATION OF THE THIGH BY MEANS OF MIXED FLAPS. The long anterior and short posterior flaps consist of skin and muscle, and are both fashioned from without inwards.

and subcutaneous tissue only is that they can be brought together more easily and with less tension than flaps cut by transfixion, or containing much muscle, in both of which it is difficult to tuck in the protruding muscular mass when the wound is being stitched up ; owing to its elasticity the skin retracts considerably, leaving the muscles protruding beyond it. After transfixion operations it is not infrequently necessary to cut away a quantity of muscle before the flaps can be sewn up without tension.

The Length of the Flaps.—It is important to remember that the skin is a very elastic structure and retracts considerably after it has been divided ; the skin flap therefore undergoes considerable shortening after it has been raised. Moreover, the muscles retract and not only become shorter themselves, but pull the skin up along with them. Although the

skin can be stretched to its original length again when the wound is stitched up, there is some risk of interfering with its vascular supply in doing this, and, therefore the flaps should always be cut longer than is necessary just to cover the ends of the bone. If no retraction of the soft parts had to be taken into consideration, it is obvious that the combined length of the two flaps ought to be equal to the diameter of the limb at the point where the bone is to be divided ; but as a matter of practice it is found that if the flaps be made this length, they will provide insufficient covering on account of the retraction we have alluded to. In order to allow for this, therefore, they should be at least one-third longer than the diameter of the limb at the point of section of the bone. It was formerly the custom to cut flaps even longer than this, with the object of avoiding even the slightest tension upon the stitches.

FIG. 219.—HOW TO ESTIMATE THE LENGTH OF THE FLAPS WHEN AMPUTATING. The transverse diameter of the limb at the point where the bone is to be sawn is ascertained. This is position *a*. Keeping the thumb in its original position, and maintaining the distance between it and the forefinger, the hand is rotated into position *b* ; this enables the length of the diameter of the limb to be marked along the thigh. This is for an amputation by lateral flaps, and the length of each flap should be two-thirds of this measurement.

Now that we are sure of obtaining union by first intention, however, a slight amount of stretching of the skin flap is of no consequence ; while it is very important to avoid creating a long bag of skin at the end of the stump, in which blood and serum may accumulate and interfere with union. Another point of great importance nowadays is that unduly long flaps entail an unnecessarily high division of bone. At the same time, if the beginner be in doubt as to the length of his flaps, it is better to cut them too long than too short. It is a simple matter to cut them down afterwards, and this is far better than cutting the flaps too short and being obliged to take away more bone in order to enable them to come together. The point of section of the bone should always be the fixed point which is determined upon before commencing the operation.

How to estimate the Length of the Flaps.—The length of the flap may be estimated roughly by spanning the limb at the point where it is proposed to divide the bone without compressing the soft parts. If

antero-posterior flaps are to be made, the antero-posterior diameter of the limb should be spanned whilst the lateral diameter is estimated when lateral flaps are to be cut. Having done this, the thumb should be kept stationary, whilst the rest of the hand is rotated upon it, without altering the distance between the thumb and the forefinger, so as to bring the latter vertically below the former (see Fig. 219). The distance thus marked off will indicate roughly the length of the anterior flap, and a third of it that of the posterior. When an anterior flap only is required, the span thus marked out will require lengthening by about a third.

THE RACKET METHOD.

Many other methods are employed, the one most in favour being the so-called 'racket incision.' In disarticulations at the metacarpo-

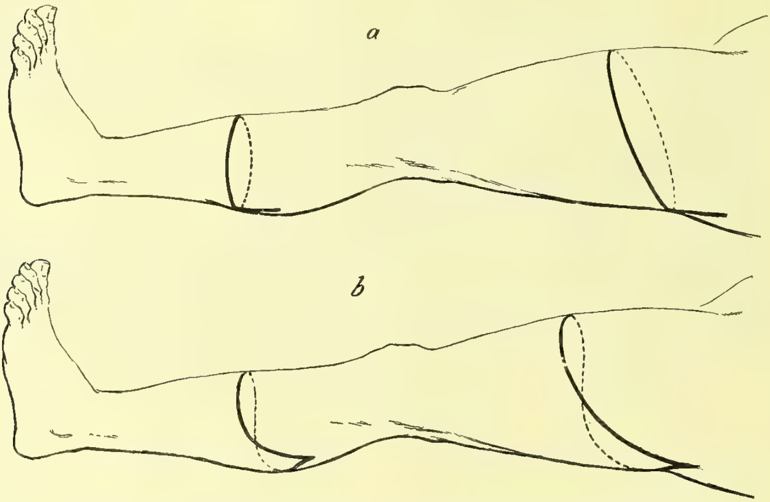

FIG. 220.—TYPES OF RACKET-SHAPED INCISIONS. In *a* are seen the primary types, the simple circular incision with the vertical handle. In the leg the incision is transverse to the long axis of the limb, in the thigh it is oblique. *b* shows the evolution of the 'hooded flap' (in the leg) and the 'oblique lanceolate' incision of Kocher (in the thigh) by sloping the incision gradually from the greatest transverse diameter of the racket to the upper limit of the handle.

phalangeal joints, for instance (see p. 510), this is a very useful method. The racket incision is really a combination of a circular with a vertical incision, the advantage being that the bone can be cleared considerably higher up than the base of the flap without having to make a second vertical incision. It is, however, much more suited for disarticulations than true amputations, since it is difficult to apply a saw without adding a second vertical incision (see Fig. 220, *a*).

Other Modifications.—The racket method, or some modification of it,

is applicable to a large number of cases. A useful adaptation has been introduced for amputations in the lower extremity. In this, the oval of the racket, instead of starting from the lower end of the vertical incision or handle, begins to diverge almost from the very commencement, so that practically there is no vertical incision at all, the flap being a single long oblique one (see Fig. 220, *b*). Anterior oblique flaps made in this way in the lower extremity fall over the end of the bone and produce a more or less vertical cicatrix situated well behind the bone. This form of flap is often spoken of as the 'hooded flap.'

These are the general types, but in addition there are a large number of special amputations for use in particular situations which will be described in due course.

IRREGULAR AMPUTATIONS.

While, however, it is well to be intimately acquainted with all the typical methods of amputation suitable for different situations, it is of extreme practical importance for the surgeon to remember that he can modify any of these to meet the varying circumstances of any individual case, and that he may use lateral, oblique, or irregular flaps according to the nature of the case with which he is dealing, so long as he is thereby enabled to provide a satisfactory stump without sacrificing more of the limb than is absolutely necessary. While no doubt the set operations may be of use in cases of disease, the patient's interests are nearly always better served, in the majority of cases in which the surgeon is nowadays called upon to amputate, by some irregular form of amputation than by one on old-fashioned lines.

METHOD OF PERFORMING A TYPICAL AMPUTATION.

We shall describe a typical amputation by the flap method, and its after-treatment, in order to emphasise various details that must be attended to both before and after the operation.

DISINFECTION.—This point is dealt with fully in Vol. I. p. 100. The skin should be shaved for a considerable distance around the proposed area of operation and then disinfected in the most careful manner some hours before the operation if possible ; a gauze dressing is put on, and finally the disinfection is again repeated when the patient is under the anæsthetic. When there are septic sinuses or ulcerated areas in the immediate vicinity of the amputation, these should be scraped out immediately before the operation and stuffed with small pieces of sponge impregnated with undiluted carbolic acid. The skin in the neighbourhood of the sinuses should be covered with a wet dressing wrung out of a 1 in 20 carbolic acid or a 1 in 500 sublimate solution, extending almost up to the lowest limit of the flaps and firmly bandaged on with a

sterilised bandage, so as to prevent the discharge from the sinuses finding its way into the region of the amputation wound during the operation. Even when there are no septic areas, it is always well to wrap up the whole of the limb to be removed in a towel soaked in a 1 in 20 carbolic acid solution, as it is difficult to render the whole limb aseptic. The assistant, to whom the task of holding the limb is entrusted, can then be allowed to take part in the operation subsequently without risk of infecting the wound. Wherever it is possible, however, the limb should be in charge of an assistant who will have nothing to do with the rest of the operation.

PREVENTION OF HÆMORRHAGE. — The arrest of hæmorrhage during the amputation was formerly effected by digital compression of the main vessel, but although this may be necessary even now in some operations, such as those about the shoulder-joint, the method is risky and comparatively ineffectual. The blood-supply of the stump is generally derived from more than one large vessel, and compression of the main arterial trunk does not arrest all the bleeding. Moreover, the assistant is apt to relax the pressure at an inconvenient moment. Whenever there is room to permit of its use, the safest and simplest plan is to adopt Esmarch's method and encircle the limb by elastic tubing or by an elastic bandage.

Esmarch's Method.—In Esmarch's complete method the limb is bandaged spirally with an elastic bandage from the extremity to a point well above the region of amputation. At the upper limit of this bandage a length of india-rubber tubing is stretched and wound horizontally around the limb, and when this is fastened in position, the spiral elastic bandage is removed. By this means, nearly all the blood in the limb is forced into the general circulation and is thus saved to the patient. There are, however, two important conditions in which the objections to the method are so great as to render it inapplicable. Should the amputation be for malignant tumour, the compression exerted by the elastic bandage may force portions of tumour substance into the circulation, and thus give rise to secondary deposits elsewhere. Again, in septic conditions, as, for example, septic sinuses or cellulitis, pus may be forced by the bandage through the interstices of the tissues and may lead to general infection.

Lister's Method.—A plan that is equally efficacious in rendering the limb bloodless but free from the above objections is that of Lord Lister, who elevated the limb for a few minutes before applying the tubing. The effect of this is to empty the veins by gravity and to cause the arteries to contract reflexly, so that, on the one hand, all the venous blood runs out of the limb, while, on the other, comparatively little arterial blood finds its way into it. The tubing is applied horizontally as high above the seat of amputation as the anatomical conditions of the parts allow, while the limb is in the elevated position. By this

method as little blood is lost as when Esmarch's complete method is adopted. It is important to remember that the limb should not be kept elevated too long before the tubing is applied, as otherwise the arteries will recover and more blood will flow into the limb.

Seat of the Tourniquet.—The tourniquet should be applied as far away from the amputation area as possible ; if applied too near to the seat of operation it will prevent proper retraction of the muscles, because it binds them to the bone. Moreover, the band is apt to slip off over the flaps when the bone has been sawn.

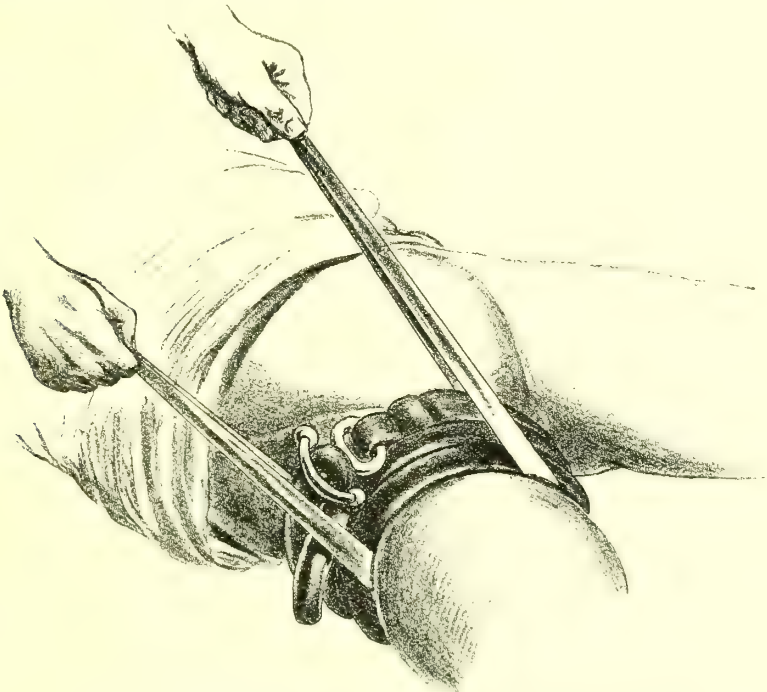

FIG. 221.—HOW TO PREVENT ESMARCH'S TUBING FROM SLIPPING DURING AN AMPUTATION THROUGH THE THIGH. Both the tubing and the strips of bandage with which they are pulled upwards should be disinfected before use.

Material for the Tourniquet.—In the lower extremity, a band of stout india-rubber tubing is the best material for a tourniquet ; the muscles are numerous and fleshy, and considerable force is required to arrest the circulation. In the upper extremity, however, stout tubing may cause undue pressure upon the nerves, and a better plan is to use a broad elastic bandage wound horizontally around the limb several times ; this exerts more evenly diffused pressure. The tourniquet, either india-rubber or elastic bandage, should be always sterilised by boiling before use. The chief drawback to the use of the elastic tourniquet is that free and persistent oozing from the stump always follows its removal In most

amputations, however, it is unnecessary to keep the tourniquet in position long enough to produce any lasting paralysis of the vessels, and therefore the objection to its use is not so great in the case of amputation as it is in various other more prolonged operations.

In amputating through the middle third of the thigh the circulation can be readily controlled by means of a stout india-rubber cord, passed around the upper limit of the limb. This, however, is apt to slip off over the flaps after the femur has been divided, and to prevent this from happening it is well to take two strips of sterilised bandage of sufficient length and lay them vertically over the limb, one on either side, and

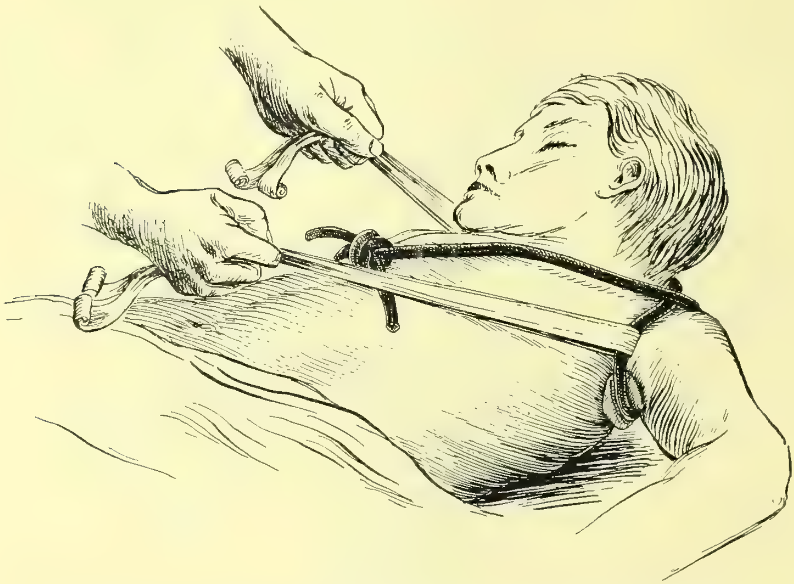

FIG. 222.—METHOD OF CONTROLLING HÆMORRHAGE IN AMPUTATIONS OF THE UPPER ARM. The rubber tubing is applied in a figure-of-eight around the shoulder, over a pad in the axilla, and is kept from slipping off when the bone is sawn by the slips of bandage passed beneath it front and back, and held as depicted above.

then to apply the elastic tube over these. When the tubing is in position, the pieces of bandage are converted into loops by seizing the two ends, and these are pulled upon throughout the operation by an assistant, and thus the tubing is prevented from slipping (see Fig. 221). The assistant to whom this duty is entrusted may subsequently compress the femoral artery at the groin when the tourniquet is removed, whilst the bleeding vessels are being picked up in the flaps.

When the amputation has to be done high up in the arm, the best way to arrest the circulation through the limb preparatory to the operation is to place a sufficiently firm pad in the axilla and apply over it a piece of stout india-rubber tubing in a figure-of-eight, around the

axilla, crossing over the outer end of the clavicle, the two ends being finally tied beneath the opposite axilla. There may be a tendency for the tubing thus applied to slip if it encroaches upon the field of operation, and the plan described in the preceding paragraph may be employed to avoid this (see Fig. 222). If no assistant be available, the ends of the two bandages can be tied together over the root of the neck upon the opposite side. On the whole, however, the simplest plan of controlling the circulation when the amputation is to be performed high up through the humerus by the modified circular method, is to deepen the incision and expose the brachial artery after the anterior flap has been cut, and then to divide it between two ligatures before proceeding further with the operation. Care must be taken not to damage the artery above the point of ligature in the subsequent steps of the operation.

In certain situations, such as the shoulder and the hip, the circular elastic compression above described cannot be applied. Special means have then to be adopted.

In disarticulation at the shoulder-joint it is difficult to prevent bleeding with any certainty. Many plans have been proposed for this purpose, that most commonly employed being either digital or instrumental compression of the subclavian artery as it crosses the first rib. In order to do this efficiently it is necessary to make an incision through the skin and deep fascia just over the clavicle as for ligature of the third part of the vessel (see p. 196), and through this to introduce the thumb or a special instrument called a 'key' [1] to compress the vessel. The objections to this are that it necessitates a second wound, and the compression is uncertain, since the 'key' may be displaced during the manipulations attendant upon the removal of the limb, or the assistants' fingers may become tired. The safest plan is to secure and divide the artery in the axilla between two ligatures at the commencement of the operation. The incision for this purpose may often be so planned as to mark out one of the flaps.

In disarticulation at the hip-joint various contrivances have been employed for controlling the circulation, such as abdominal tourniquets, transfixion pins and forceps, rectal levers or digital pressure on the aorta or common iliac through an abdominal incision; but these are really unnecessary if the operation be begun by tying the common femoral vessels. In one form of operation the incision for this purpose forms part of the incision for the disarticulation, and in Furneaux Jordan's operation it is a slight addition. If this be done, the only vessels of consequence not controlled are the branches of the gluteal and obturator arteries.

When Furneaux Jordan's amputation is being done however, the

[1] This consists of a ⊥-shaped piece of wood, the cross-piece being short and covered with india-rubber. The instrument should be sterilised by boiling before use.

surgeon is generally anxious to save even the time consumed in ligaturing and dividing the femoral vessels before he begins amputating; and Fig. 223 shows how the circulation can be controlled effectually and safely by means of well-applied elastic tubing which can be made to control the gluteal and sciatic as well as the femoral vessels, and is therefore superior to preliminary ligature of the latter vessels. It also shows how the bandage is kept from slipping during the operation.

Fig. 224 shows how the india-rubber tubing may be applied circularly round the groin and kept from slipping by transfixing the soft

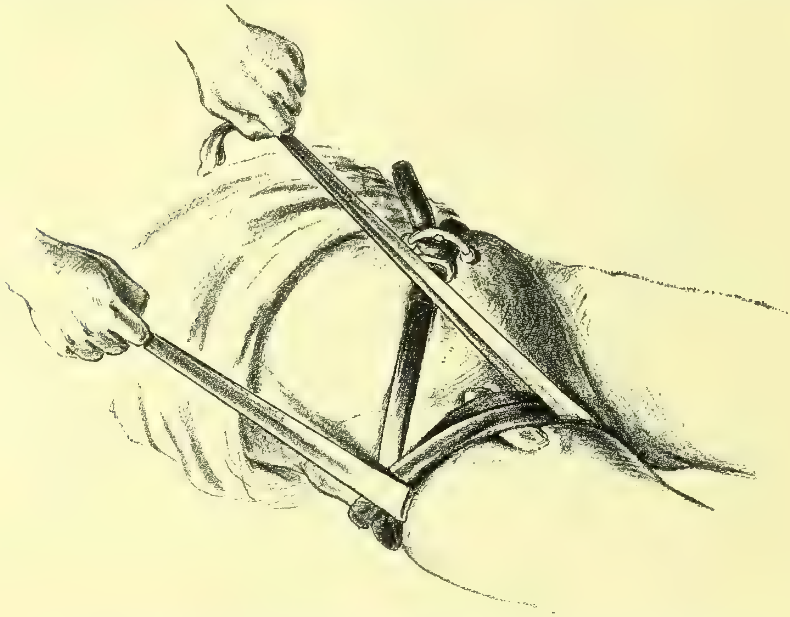

FIG. 223.—TOURNIQUET FOR USE IN AMPUTATIONS HIGH UP THE THIGH. There is a sterilised pad over the line of the femoral vessels which are compressed against the pelvic brim.

parts with the stout steel pins introduced by Wyeth. The sharp points are afterwards protected by cork.

The transfixion pressure forceps, introduced by Mr. Lynn Thomas (see Fig. 225), are admirable if the surgeon be short-handed and cannot spare an assistant to look after the rubber tourniquet. They may be used for controlling the common femoral, or the first or third parts of the axillary. They are easy to apply, since they only require a small skin incision for the introduction of the probe-pointed end, and they are quite sure in their action. A little care is required to avoid bruising the tissues.

PREVENTION OF SHOCK.—In the more important amputa-

tions, and particularly in feeble subjects, the prevention of shock is a matter of the highest importance. The various measures both for the prophylaxis and treatment of shock have already been dealt with in detail in Vol. I. p. 117. The more important of these are the use of a heated table and a warm room and the preliminary administration of adrenalin or pituitary extract and rectal enemata of brandy and beef tea. In some cases the employment of spinal analgesia (see Vol. I. p. 486) may be of value.

A good plan in these cases, in which severe shock is expected, is to apply a rubber band horizontally round the upper part of the thighs so as to retain blood in them. As soon as the main vessels have been tied the bands are removed and the limbs elevated, thus allowing the blood retained in the limbs to circulate once more and thus practically to transfuse the patient. As a rule, however, there is but little shock, even in amputations through the thigh, except in cases of primary amputation done for an injury in which profound shock is present before the operation is done.

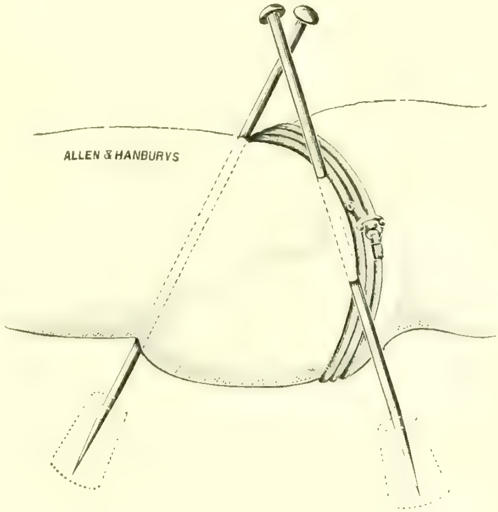

FIG. 224.—WYETH'S PINS APPLIED FOR AN AMPUTATION HIGH UP THE THIGH. The outer pin should pass well beneath the tensor fasciæ femoris, and the inner one should go beneath the adductors. They then obviate all risk of the circular tubing slipping. A pad may be placed over the line of the femoral and gluteal vessels for additional security.

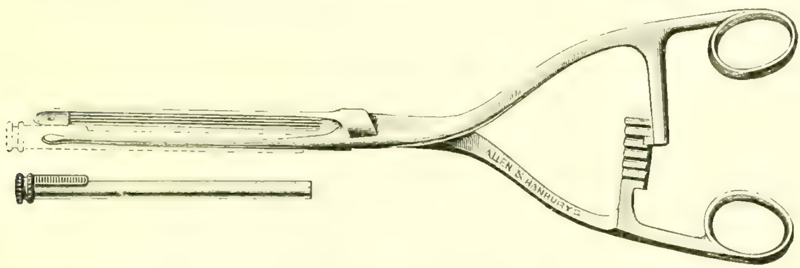

FIG. 225.—LYNN THOMAS'S HÆMOSTATIC FORCEPS. The probe-pointed blade underruns the tissues containing the vessels to be compressed, while the other blade exerts pressure on the skin.

THE AMPUTATING KNIFE.—The amputating knife should not be too long, as otherwise it is difficult to mark out the flaps and to

dissect them up rapidly and accurately. When the flaps are cut from without inwards, as is done nowadays, the knife should not be more than six inches long. This gives sufficient control over the knife, while at the same time it enables the surgeon to divide the muscles by broad sweeps of the blade. Should, however, a circular amputation be performed, or the flaps be cut by transfixion, the knife must be nearly half as long again as the diameter of the limb at the point at which the bone is to be sawn.

CUTTING THE FLAPS.—The surgeon should stand on the patient's right of the limb to be removed, and the first points for decision are the spot at which the bone is to be divided and the length and position of the flaps. The directions for ascertaining the length of the flaps have already been given (see p. 489). They should be cut from without inwards rather than by transfixion, which was formerly much in vogue on account of its greater rapidity. The great advantage of cutting the flaps from without inwards is that the surgeon is thereby enabled to gauge the relative amount of skin and muscle much more easily and accurately. The extra time consumed in the operation is of no practical importance.

The *shape of the flaps* is of great importance ; they should be practically rectangular, with merely the corners rounded off. A common fault with beginners is to make the flaps too pointed ; the incision marking out the flap is made to approach the middle line almost from the first, whereas it should be carried down almost vertically parallel to the long axis of the limb, nearly to the lower border of the flap, where it should curve slightly towards the middle line and then run transversely across the limb to a corresponding point on the opposite side, when, after a slight curve upwards, it should be carried almost vertically up to a point opposite to that from which it started. In order to prevent mistakes at a later stage it is well for a beginner to mark out the posterior flap before dissecting up the anterior one. This flap is generally about a third the length of the anterior, and is made by drawing the knife transversely across the back of the limb, just rounding off the flap where this incision joins the lateral vertical ones.

In cutting the flaps the edge of the knife must be held strictly at right angles to the surface of the skin, as otherwise the edge of the flap will be bevelled and imperfectly nourished, and may lose its vitality. The incisions marking out the flaps should extend through the skin, subcutaneous tissue and deep fascia ; the latter must always be taken up with the skin as it contains the main blood-supply of the superficial structures. The skin flap is then gradually raised from its free edge. In a good many cases the flap will consist of the skin and fascia only, but in the example we are considering—the so-called 'mixed' flap—the first two inches comprise nothing but the deep fascia and the structures above it, but after that the knife is made to divide the muscle gradually and obliquely, so that more and more of this structure is taken up as the flap progresses,

until, as its base is reached, everything is being raised right down to the bone (see Fig. 226). When the anterior flap has been raised, it is held out of the way by an assistant, whilst the limb is elevated and the posterior flap is fashioned similarly from without inwards. Some authorities recommend that this flap should be cut by transfixion ; this plan is no doubt more rapid, but it has the objection that the muscles are divided on almost the same level as the skin, and therefore there may be difficulty in stitching up the stump. The only situation in which transfixion is really advantageous is a region such as the lower third of the thigh or

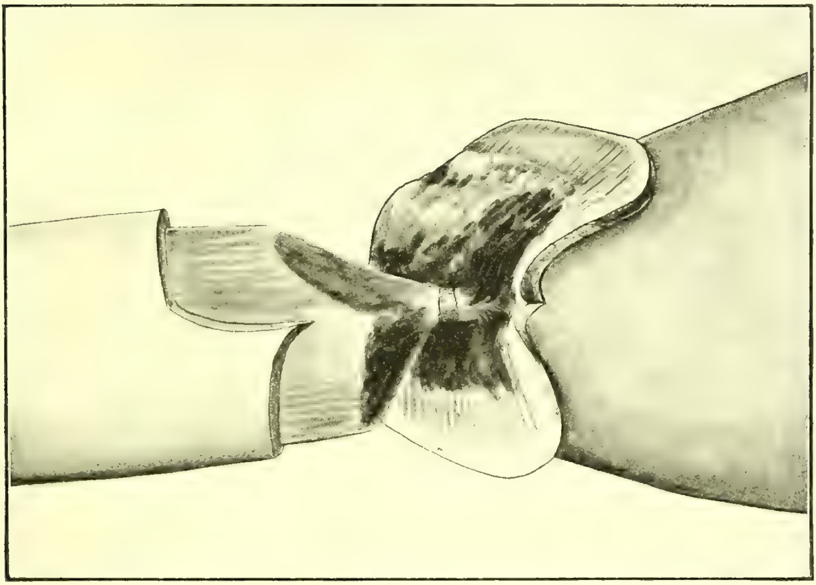

FIG. 226.—AMPUTATION OF THE THIGH BY MEANS OF MIXED FLAPS. The long anterior and short posterior flaps consist of skin and muscle and are fashioned from without inwards as described in the text.

the forearm, where the structures divided by transfixion are mainly tendinous. As a general rule a neater and more satisfactory stump is obtained by the slightly slower but much more careful method of cutting both flaps from without inwards.

SAWING THE BONE.—After the flaps have been raised down to the bone they are retracted by an assistant and the periosteum is divided by a circular sweep. A cuff of periosteum (see p. 484) may now be raised if the operator desires. The knife is then laid aside, the heel of a fine-cut saw is pressed firmly over the bone and a groove cut by drawing the saw towards the operator from the heel to the point. While the groove is being cut, the saw may be steadied by pressing the tip of the left thumb

upon the bone just above the proposed line of section and resting the fully-flexed terminal inter-phalangeal joint against the blade of the saw; the blade of the saw is pressed against this fixed point and cannot slip upwards. The bone is sawn through by light and rapid sweeps, the assistant taking care to hold the limb absolutely horizontal. This is a somewhat difficult task as he is apt, on the one hand, to push the limb up, in which case the saw becomes locked, while, on the other, if reproved for doing this, he is apt to depress it unduly, so that, after the saw has divided the greater part of the bone, the remainder snaps off. To assist in maintaining the horizontal position of the limb, the operator should grasp the bone firmly in his left hand just above the point of division. If any sharp spicules of bone are left they should be removed by cutting pliers applied with the flat side against the sawn surface. When the bone is subcutaneous and a sharp edge would otherwise be left beneath the skin flap, it is an excellent plan to saw off the projecting portion obliquely (see Fig. 227).

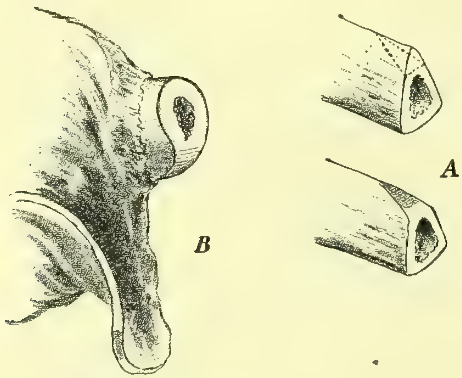

Fig. 227.—Methods of Rounding off the End of the Bone in Amputations. *A* shows the direction of the saw-cut and the appearance of the bone-end after the sharp tibial crest has been sawn off. *B* shows the result after treating the linea aspera of the femur in a similar manner.

SECURING THE VESSELS. — After the limb has been removed, the flaps are laid down in position to see if they are of sufficient length; if this inspection be satisfactory, the surgeon proceeds to ligature the main vessels which are readily recognised both by their anatomical situation and by their appearance; the large veins should be picked up and ligatured as well as the arteries. The best material for ligature is moderately stout catgut. After the main vessels have been tied, a few others may be identified and clamped before the tourniquet is removed by squeezing the muscles, and thus causing a drop of blood to exude from the cut ends of the vessels. Then an assistant should be told off to compress the main artery of the limb whilst the tourniquet is removed, and it is a good plan to fold one of the flaps firmly over a large hot sponge so as to stop the oozing from it, whilst the bleeding points are being picked up in the other flap. If several largish vessels bleed, the assistant can compress the main vessel until they have been secured; by proceeding in this way very little blood need be lost. While the vessels are being picked up, the limb should be raised into the vertical position. It is well to tie all the clamped vessels with fine catgut; no doubt many of them would

stop oozing after having been clamped for a little while, but time is saved by tying them all and there is less risk of the flaps becoming separated by blood-clot subsequently. As soon as the vessels have been tied, the main nerves should be identified, seized with forceps, pulled down and cut short ; the same may be done with any tendons projecting in the stump.

SUTURING THE FLAPS.—After the bleeding has been arrested, the flaps are brought together with a continuous suture. In order to make sure that the flaps shall be united accurately, a few interrupted sutures may be inserted deeply through the flaps before the continuous one is put in, as they serve to keep them temporarily in position. One of these may be introduced through the centre of the flaps and one on either side.

DRAINAGE.—A drainage tube should always be inserted and should be kept in for two or three days ; otherwise the stump is apt to fill with blood, owing chiefly to the oozing following the use of the tourniquet, and this would cause delay in healing. Sloughing of the flaps has been known to occur from the pressure exerted by the blood distending them. A drainage tube is all the more necessary because it is impossible to apply sufficient pressure to stop capillary oozing in amputation wounds without running the risk of causing sloughing of the flaps. The drainage tube (generally about No. 14) should be introduced if possible at the most dependent angle of the wound, and the one farthest from any possible source of septic infection—a point of importance in amputation in the upper third of the thigh or disarticulation at the hip-joint. When the most dependent point would bring the tube too near to some possible source of infection the tube must be inserted farther away, for the dependent position is of comparatively slight consequence.

DRESSINGS.—A very large dressing should be applied, because otherwise the movements of the patient may uncover the wound. If the stump be short, a broad strip of adhesive plaster may be applied round the upper part of the dressing, half on the skin and half on the bandage, so as to prevent it from slipping down. It is not uncommon for the stump to jerk about freely after amputation, and in order to obviate this a splint should always be applied.

SPLINTS.—For amputations of the lower extremity a trough of Gooch's splinting (see p. 264), made to encircle rather more than half the circumference of the limb, is excellent. The splint is covered with jaconet, upon which is laid a large mass of salicylic wool. The stump, with its dressing applied, is placed upon the splint, and padding arranged so as to afford equal support in all directions. The bandage which fixes on the splint must be applied from the extremity upwards, and special care must be taken that the upper turns do not exert any constriction upon the limb ; if they do, the venous return will be interfered with, and increased oozing will ensue. In amputations through the

thigh, the bandages fixing both the dressings and the splint must be carried up round the pelvis, as otherwise they will slip off. After the limb has been secured to the splint it should be raised upon an inclined plane or on pillows. The latter generally suffice in amputation through the leg, and the limb may be fastened to the pillows by means of bandages. In the thigh it is well to fasten the limb and splint on an inclined plane of wood, weighted by a heavy sandbag or by weights, so that it cannot be moved by the jerking of the limb.

AFTER-TREATMENT.—The dressings should be changed at the end of the first twenty-four hours if the oozing has reached the surface, as is practically always the case, The dressings will also probably require changing on the second day for the same reason, and the drainage tube can be left out on that day or the next, except when there is accumulation of blood-clot between the flaps; in these cases it should be retained for two or three days longer. Occasionally, however, particularly in drunkards, the blood does not coagulate properly, and tarry blood may be squeezed out for several days after the operation. When this is the case, the drainage tube should not be discontinued until it has ceased. The continuous suture can generally be removed in ten days, but in the more important amputations, it is well to leave the interrupted sutures in position for a week longer so as to prevent separation of the flaps from accidental damage.

Support to the Stump.—When the wound has nearly healed, it may be necessary, particularly when the flaps have been cut a little short and there is consequently tension upon them, to employ some special method of bandaging the stump. The object of the bandage is to push down the muscles over the end of the bone and prevent retraction of the flap, and therefore the stump must be bandaged from above downwards. A special stump bandage is also called for when a large, heavy posterior flap has been turned forwards, as this flap, if unsupported, would tend to drag the scar backwards over the end of the bone.

Before applying this bandage, considerable support may be given to the flaps by the arrangement shown in Fig. 228. A single layer of dry gauze, the width of the transverse diameter of the limb, is fastened by collodion to the skin for a considerable distance above the divided end of the bone. When the collodion is dry, an assistant, grasping the limb above, pushes the tissues well down over the bone, and the free end of the gauze is then pulled upon and folded down over the end of the stump and fastened to the opposite surface of the limb by more collodion, the soft parts being held in position until the collodion is dry. Outside this a bandage may be applied; if the bandage be wetted with 1 in 2000 sublimate solution it adheres better and obtains a firmer hold upon the limb because it shrinks as it dries. An assistant pulls the soft parts down over the end of the bone, and the bandage is commenced a considerable distance above the end of the stump. From this point it is made to com-

press the limb evenly from above downwards either by the figure-of-eight method or by reversing, so as to push down and fix the skin and the muscles, and thus to relieve tension on the stump. When the free end of the stump is nearly reached, the bandage is finished off as a typical *stump bandage*, as follows: The last circular turn is fixed by the thumb at the centre of the limb in front, and the bandage is then brought vertically downwards over the centre of the free end of the stump, and carried up to a corresponding point on the centre of the limb behind, where it is fixed by the forefinger. From this point the bandage is again brought over the free end of the stump, slightly to the opposite side of the middle line, up

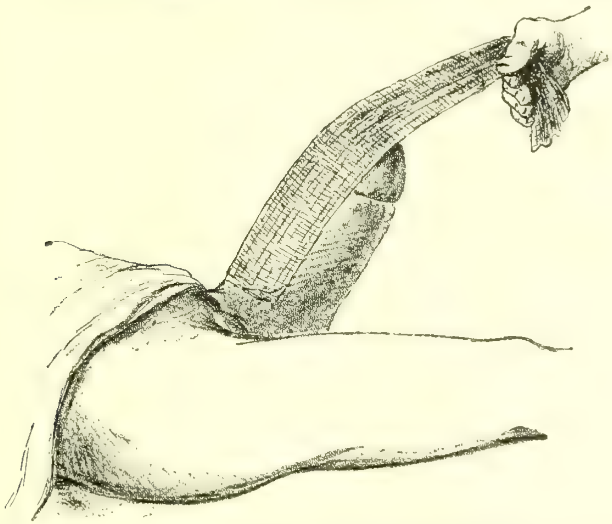

Fig. 228.—Gauze and Collodion Bandage for an Amputation Stump. When the collodion fastening the gauze to the front of the thigh is dry, the soft parts are pushed well down, and the gauze is then folded down over the end of the stump, applied to the posterior surface of the thigh and secured with collodion to it, being held firm until the collodion is quite dry.

to the thumb, beneath which it is caught, and then similar turns are carried backwards and forwards to alternate sides of the middle line, each turn overlapping its predecessor by about two-thirds of its width until the whole of the end of the stump has been covered (see Fig. 229). Finally these vertical turns are caught and fastened beneath a few turns of the bandage carried circularly around the limb, leaving the whole stump well covered in and firmly supported.

In applying this bandage it is important that the turns which pass over the end of the stump should always be begun on the side of the limb on which the longer flap is. For example, if the anterior flap be the longer, the bandage should be carried from the anterior surface of the limb over the end of the bone and up on to the posterior surface. Should the long flap be the posterior one, the bandage should be commenced

on the posterior surface. In an amputation through the thigh, the upper part of the bandage should be carried round the pelvis in the form of a spica, so as to prevent its slipping.

When there is a long heavy posterior flap, as in Syme's amputation, the chief object of a stump bandage is to support the flap and push it well forwards. It must therefore be employed for some weeks after the wound has healed, as otherwise the scar may be pulled down over the end of the bone. In this case the bandage is commenced on the posterior aspect of the limb, carried downwards over the flap and upwards on to the anterior surface, and then back again and so on. When it is necessary to support

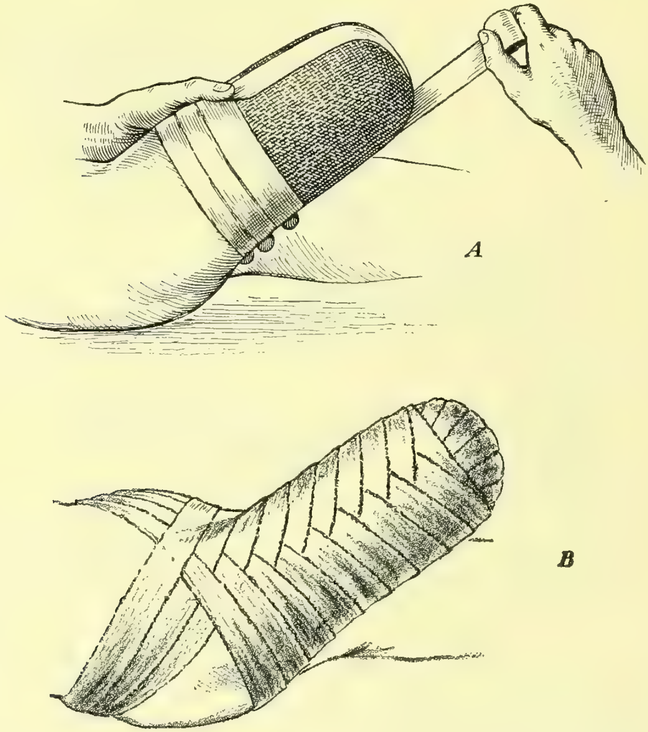

Fig. 229.—The Stump Bandage. In *A* is shown the method of commencing to cover in the end of the stump. The direction of the bandage is changed from circular to antero-posterior by placing the thumb upon it as shown above. The bandage is then carried over the end of the stump and up along its posterior surface, where it is caught beneath the forefinger and then brought back again, slightly to one side of the middle line, beneath the thumb once more. In *B* the bandage is shown completed and carried up as a spica around the pelvis.

the stump by bandages in this manner, the limb should be put on the splint in such a position that the utmost possible relaxation of the long flap is obtained.

When an Amputation becomes Septic.—This accident may happen

either from some error in the management of the case or as the result of an amputation carried out through a septic region. The treatment will be that of a septic wound (see Vol. I. p. 155). The most important point is the establishment of free drainage. When the septic condition has subsided and granulation is established, attention must be directed to preventing retraction of the flaps. This is best done by the gauze and collodion dressing just referred to, which may be put on next the skin, and also by the stump bandage which is applied outside the dressings in the manner just described. Special care has to be taken to keep the limb on the splint in a position that will relax the long flap as much as possible until the wound has healed. In some cases it is well to stitch up the wound again after laying a drainage tube between the two surfaces.

FAULTY STUMPS.

Apart from the question of sepsis in amputation wounds, which ought not to occur at the present day, a stump may be faulty either from adhesion of the cicatrix to the end of the bone, with possibly involvement of nerves in the scar, or from the formation of what is known as a conical stump.

ADHERENT CICATRIX.—This condition has already been referred to (see p. 483); it usually results from sepsis and subsequent healing by granulation, which is followed by adhesion of the flaps and the scar to the bone. It may result from faulty planning of the flaps, however, even after a perfectly aseptic operation.

An adherent cicatrix often gives rise to very great pain on pressure, even when the larger nerves have been cut short as recommended above, and is then due to the implication in the cicatrix of the smaller nerve branches, which become bulbous and give rise to excessive pain. Besides the neuralgic condition of a stump in which the cicatrix is adherent, there is apt to be persistent ulceration in the scar, owing to the low vitality of the cicatricial tissue which breaks down upon the slightest pressure. In stumps of this kind the nutrition of the entire end of the stump is apt to be defective; it is cold, livid in colour, and liable to be affected by obstinate ulceration.

Treatment.—The best plan is to re-amputate in all cases of painful and adherent cicatrix. The other alternative is to cut away the cicatrix, open up the wound and resect a portion of the bone. The latter method is, however, very likely to be followed by fresh adhesion to the bone and recurrence of the symptoms, and therefore a new clean amputation is much better. When, however, an important joint, such as the knee, would have to be sacrificed if fresh flaps were made, it may be worth while to try the effect of removing a portion of the bone after excising the old cicatrix, and if this fails, recourse can still be had to amputation above the joint.

CONICAL STUMP.—The so-called conical stump may result from three causes. In the first place the flaps may be so badly planned at the time of the operation that they can only be made to meet with difficulty over the end of the bone, the result being that the skin becomes more and more stretched over the end of the bone as the muscles waste, and the stump therefore becomes conical. Secondly, the condition may result from excessive wasting and contraction of the muscles after an amputation in which the flaps have been accurately fashioned at the time of the operation ; this generally occurs in very muscular subjects in whom suppuration and granulation have occurred. Lastly, it not infrequently happens that a perfectly successful amputation is performed in young subjects, but the stump gradually becomes conical. This appears to depend on want of proper relation between the development of the soft parts and the growth of the bone, the latter structure growing out of all proportion to the former.

Treatment.—It is generally sufficient to open the wound, and to remove as much bone as may be necessary to make a satisfactory stump. When the conical condition is produced by excessive growth of the bone it may be necessary to have recourse to operation more than once, for the stump may again become conical after a time. Hence, in operating on a conical stump for the first time, it is well to excise what might at first sight appear to be an unnecessary amount of bone, with a view of obviating the necessity for a second operation for the same condition. The amount of bone removed will vary with the age of the patient ; when he is approaching the period at which growth is complete, it will not be necessary to remove as much as when he is younger, and when the bone may therefore be expected to grow considerably.

CHAPTER XXX.

AMPUTATIONS IN THE UPPER EXTREMITY.

AMPUTATIONS OF THE FINGERS.

General Considerations.—The principal point that the surgeon has to settle before he proceeds to amputate a finger is whether it is advisable to save a phalanx or a portion of a phalanx, or whether the amputation should be performed at the metacarpo-phalangeal joint and the entire finger removed. It is very important to retain even a small portion of a phalanx in most of the fingers—particularly the index and little fingers—provided that the flexor and extensor tendons can be made to act upon it. This can always be done in aseptic cases by securing the end of the divided tendon either to the orifice of the sheath, or to the periosteum in its vicinity, when the amputation is done above [1] the centre of the middle phalanx and therefore above the insertion of the flexor tendons.

DISARTICULATION OF THE TERMINAL PHALANX.

When only the last phalanx is diseased there is no dispute as to the advisability of retaining the rest of the finger, since the insertions of the flexor and extensor tendons are not completely divided in the amputation, and the movement of the inter-phalangeal joint is therefore not interfered with.

DISARTICULATION BY A LONG PALMAR FLAP.—The best method of removing the terminal phalanx is by means of a long anterior flap. This is, in fact, the only plan by which sufficient skin can be obtained to cover the head of the second phalanx without tension. Moreover the palmar flap is thick and well endowed with tactile sensation, and the cicatrix lies upon the dorsal aspect of the finger out of the way of pressure.

[1] The terms *above* and *below* are used in the upper extremity in a sense synonymous with the adjectives *proximal* and *distal* respectively. Thus 'above the centre of the middle phalanx' means 'on the proximal side of the centre,' etc.

In performing the operation the surgeon stands in front of the patient, while an assistant, standing facing him, grasps the other fingers, flexes them, and pulls them away from the affected member, so as to leave the finger to be operated on as free as possible. The surgeon takes the tip of the finger in his left hand, with the thumb upon the nail and the forefinger beneath the pulp, and flexes the last joint to about a right angle. Then, with a straight, narrow bistoury about two inches in length, a

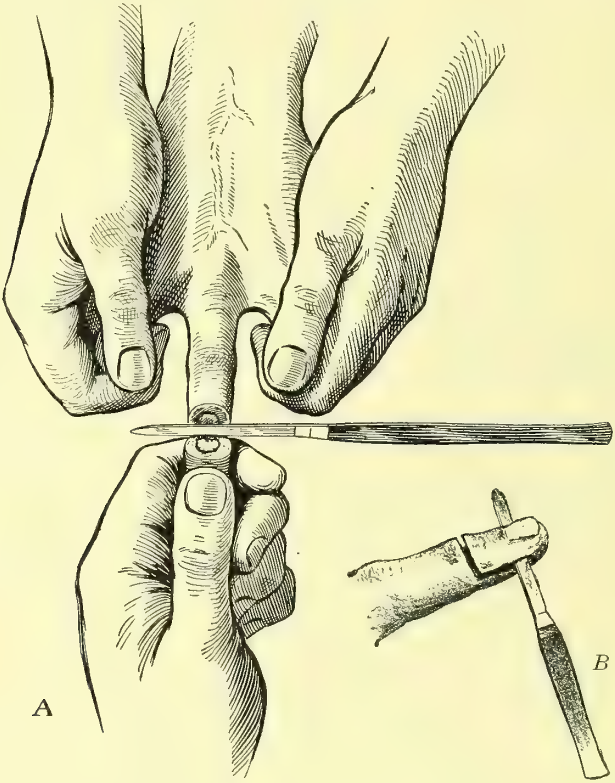

FIG. 230.—AMPUTATION OF THE TERMINAL PHALANX OF A FINGER. *A* shows the position of the limb when the transverse dorsal incision is made. The next stage is shown in *B* where the palmar flap is being fashioned.

transverse incision is made across the dorsal aspect of the distal joint, about a twelfth of an inch below the prominence, keeping the cutting edge of the knife at right angles to the skin. This incision should go direct into the articulation, dividing the lateral ligaments (see Fig. 230, *A*). The joint is then still further flexed and the terminal phalanx pulled forwards, while the knife is insinuated behind its base and made to fashion a long palmar flap by keeping the blade parallel to, and in close contact with, the palmar surface of the bone as the knife is carried down

towards the tip of the finger. When the flap is of sufficient length, which will generally be when the knife approaches the point at which the finger begins to taper to its tip, the cutting edge is turned at right angles to the skin which is then divided (see Fig. 230, *B*). Few vessels require ligature, as only the terminations of the digital arteries are divided.

In this way a rectangular palmar flap is made which can be turned up over the head of the second phalanx and united to the skin on the dorsum. A common mistake is to make the flap pointed or triangular, either from carelessness in not making the knife follow the anterior aspect of the bone closely, or from continuing the knife in the horizontal direction until it cuts its way out, instead of turning it at right angles to the skin when finishing off the flap. In order to cut the flap satisfactorily it is necessary to have a knife with a narrow blade of equal breadth throughout—in other words, a bistoury and not a scalpel.

The situation of the inter-phalangeal joint can almost always be determined by the guide given above; if not, the line of the joint is about an eighth of an inch below the level of the lowest crease on the palmar aspect of the finger. Should the surgeon not have a suitable bistoury, he can first cut the palmar flap from without inwards, and then proceed with the rest of the amputation as described above.

In aseptic cases in which the joint is healthy, the cartilage covering the head of the second phalanx may be left behind and gives no trouble. No drainage tube is required. When, however, the operation is performed for septic affections, such as whitlow, or when there has been a bad crush or lacerated wound of the tip of the finger, the articular cartilage should be removed from the head of the second phalanx as otherwise it would be almost certain to necrose. In these cases, also, it is well to introduce a fine drainage tube at one angle of the flap for two or three days.

After-treatment.—An anterior splint which extends into the palm should be applied; the one made of block-tin and used for fracture of the fingers (see p. 360) is as good as any. When the wound is aseptic, the dressing need not be changed until the stitches are taken out about the tenth day. When the wound is septic, the after-treatment will be that of a septic wound (see Vol. I. p. 155); in these cases the splint must be re-applied until the wound has healed, as otherwise the flap is likely to fall away and leave the head of the middle phalanx exposed.

AMPUTATION THROUGH THE SECOND PHALANX.

The single long palmar flap method is also applicable to amputations through the middle phalanx, the flap being cut from without inwards and the bone divided by a fine saw. When the amputation is done above the middle of the phalanx a long dorsal flap with a short palmar one will usually give a better result. In amputations above the middle of

the second phalanx the stump left will be useless unless special care be taken to provide a new attachment for the tendons, especially the flexors.

Fixation of Tendons to the Stump.—The flexor tendons should be divided on a somewhat lower level than that of the bone section. Before they are divided they should be secured by catch forceps. Should they escape and retract up their sheath, they can be protruded by flexing all the fingers and squeezing the palm downwards. At the end of the operation they should be stitched with fine catgut either to the edge of the sheath or to the periosteum on the front of the bone. They thus acquire an intimate connection with the bone, and flexion of the stump of the finger is preserved. It is not so easy to stitch the extensor tendon in a similar manner, but it is well to do so in order to get the best possible result.

AMPUTATION THROUGH THE FIRST PHALANX.

If the tendons be sutured in this manner, even a small portion of the first phalanx may be retained with advantage to the patient. If the entire phalanx can be saved, this certainly should be done, instead of sacrificing it by disarticulating at the metacarpo-phalangeal articulation, as used to be the practice. It is of great importance to save even the smallest portion of the first phalanx of the index or little fingers.

DISARTICULATION AT THE METACARPO-PHALANGEAL-JOINT.

This operation is performed more frequently than amputation through the finger itself, and is required for severe cases of whitlow, for bad crushes of the finger, and for tuberculous disease either in the form of strumous dactylitis or tuberculous joint mischief.

Importance of Retaining the Metacarpal Bone.—It is always well, if circumstances permit, to avoid interfering with the head of the metacarpal bone. It is true that removal of a finger, particularly the ring or middle finger, leaves an unsightly gap in the hand, but the hand is much more useful than it is when the head of the metacarpal has been removed. The latter procedure gives a better appearance to the hand and leaves little trace of the operation, but the power of the grasp and the general utility of the hand are considerably diminished. Certainly in men, and particularly in those who have to earn their living by manual labour, the metacarpal bone even of the index or the little finger should be left untouched. In those, however, who are not so situated and to whom the sightliness of the hand is of more importance than its strength, the head of the metacarpal bone may be removed, so as to avoid attracting attention to the gap between the fingers.

The Racket-shaped Incision.—The best operation for general use, particularly for the middle and ring fingers, is that known as the racket-shaped incision. The hand is pronated, the other fingers bent and kept out of the way by an assistant, while the surgeon, facing the hand, seizes

the finger to be removed, flexes it at the metacarpo-phalangeal joint through about half a right angle and, entering the point of the knife just above the knuckle, carries an incision directly downwards over the dorsal aspect of the phalanx nearly to the level of the edge of the web of the finger. Thence the incision passes forwards and very slightly downwards to the edge of the web. It then runs transversely across the front of the finger on a level with the crease on its palmar surface as far as the

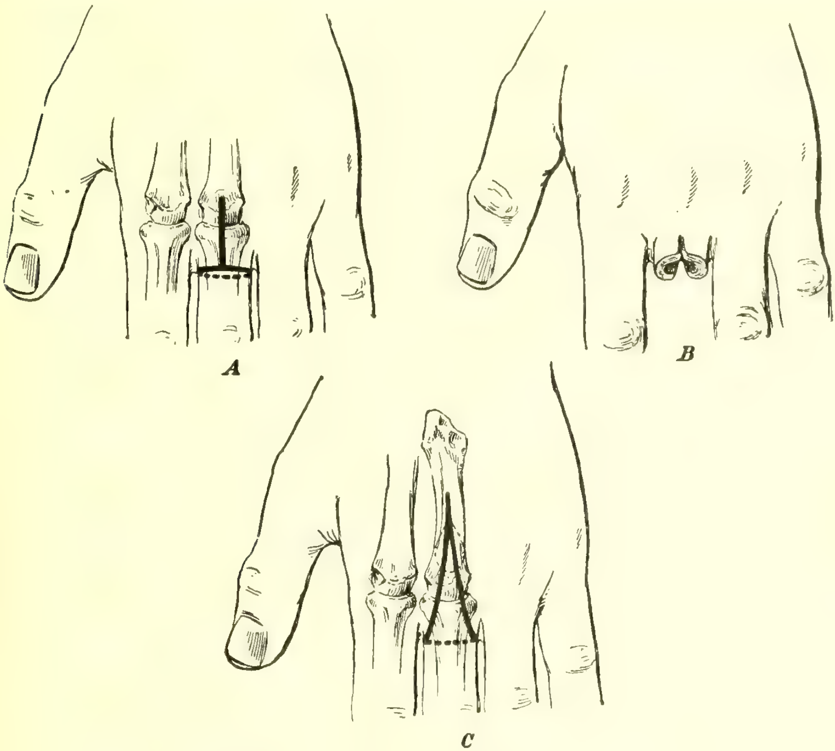

FIG. 231.—AMPUTATIONS OF THE FINGERS. *A*, the ordinary racket-shaped incision for amputation at the metacarpo-phalangeal joint. *B*, the same amputation, but with a notch made in front to improve the appearance. *C*, Incision for removal of a finger along with the head of its corresponding metacarpal bone. The oblique section through the latter is shown by the thin dotted line.

web on the opposite side, whence it is carried upwards to join the vertical incision from which it started (see Fig. 231, *A*). This incision should go down to the bone all round. The finger is then fully extended and the flaps are dissected up. If the tendons have escaped division in the first incision, they are put upon the stretch and divided. The base of the phalanx is cleared and the metacarpo-phalangeal joint is opened from the palmar surface by hyper-extending the finger and putting the anterior ligament upon the stretch ; it can then be nicked with the point of the

knife, the lateral ligaments divided and the finger removed. The only vessels requiring ligature are the digital branches of the palmar arch which will be found on either side of the head of the metacarpal bone slightly towards its anterior aspect and close to the bone. The flaps should come into apposition on approximating the fingers. Sometimes, however, particularly when the skin of the palm is very thick, an unsightly projection of skin is left at the palmar end of the incision when the flaps are brought together. This can be removed by taking out a V-shaped portion there (see Fig. 231, *B*) and this should be done after the amputation has been completed, as the surgeon can then see exactly how much skin should be taken away.

A drainage tube is unnecessary unless the case be septic. The cartilage over the head of the bone may be left, and there is no necessity for any interference with the tendons or the tendon sheaths. Should the case be septic, however, the cartilage should be removed, the tendon sheath sewn up with fine catgut and the wound sponged over with undiluted carbolic acid.

After-treatment.—The hand is placed upon an anterior splint extending some distance up the forearm, so as to fix the wrist. The fingers next the seat of amputation on either side should be fastened to one another by strips of gauze, so as to avoid all tension upon the stitches. The stitches may be removed in a week and the splint discarded.

REMOVAL OF THE HEAD OF THE METACARPAL BONE.

Should it be desired to remove the head of the metacarpal bone at the same time, this may be done by the incision shown in Fig. 231, *C*. The head of the bone is freed from the surrounding parts without opening the joint and cut off obliquely from behind downwards and forwards (see Fig. 231, *C*) by a special metacarpal saw.

AMPUTATION OF THE INDEX AND LITTLE FINGERS.

These fingers are best removed by means of Farabeuf's method (see Fig. 232, *A*), which provides an excellent covering and places the cicatrix well out of the way of pressure. The incision commences at the level of the base of the first phalanx just to the radial side of the extensor tendon of the index or the ulnar side of that of the little finger. It is carried vertically down along the extensor surface of the finger to just above the centre of the phalanx, when it is carried around the radial or ulnar sides of the respective fingers to the junction of those surfaces with the palmar. From this point the incision slopes to the edge of the web and thence back along the dorsal aspect of the hand by the shortest route to the original starting-point. By this means a large single external flap (in the case of the little finger an internal one) is made; this is dissected up to the line of the joint and disarticulation is effected. Care

must be taken not to commence the incision above the joint line, otherwise there will be insufficient covering for the large articular end of the metacarpal.

When it is desirable to remove the head of the metacarpal bone as well as the finger, the line of section through the bone should be obliquely downwards and to the opposite side. It is then also well to slope off the angle of junction between the oval of the racket and the handle, and thus to convert the incision into a long oblique one, in preference to the

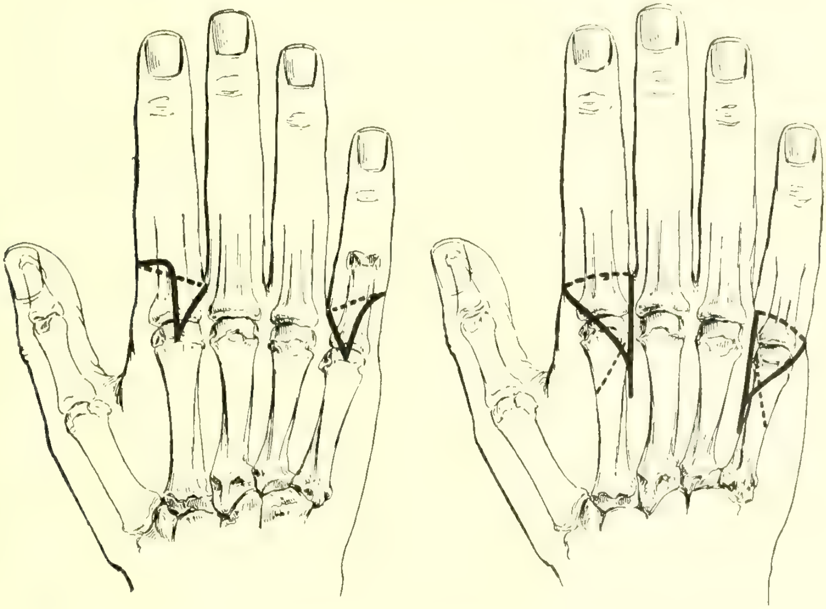

Fig. 232.—Amputations of the Index and Little Fingers. *A*, Incisions for Farabeuf's amputation at the second and fifth metacarpo-phalangeal joints. *B*, Incisions for amputations accompanied by removal of the head of the metacarpal bone. The dotted line shows the line of section through the latter.

typical racket-shaped incision (see Fig. 232, *B*). This gives a more sightly scar.

REMOVAL OF A METACARPAL BONE.

Should it be necessary to remove the metacarpal bone as well as the finger, this should be done if possible without opening the carpo-metacarpal articulation. Generally it will be sufficient to divide the bone just below its base, and this can be done by extending the vertical incision upwards. The sides of the bone can then be cleared and the shaft divided at the desired spot, when the anterior surface of the bone can be cleared by pulling it forcibly backwards.

As a rule, however, it is seldom necessary to remove the metacarpal bone as well as the finger. Excision of the metacarpal is generally required for some disease of the bone itself, such as tumour or tuberculous osteo-myelitis, and under these circumstances it is often possible to remove the metacarpal and to leave the finger intact. In place of the metacarpal bone there will then be a firm cicatrix, and the finger will be drawn up between the heads of the adjoining metacarpals, so that there is apparent shortening.

The operation may be done through a dorsal incision extending the whole length of the metacarpal bone from well above the base and diverging a little to each side opposite the knuckle (see Fig. 233). The incision should only go through the skin, and the extensor tendon should be pulled aside and carefully preserved. If the amputation be done for any other affection than tumour or periosteal disease, it is well to strip the periosteum off the bone and preserve it. The ligaments connecting the base of the metacarpal with those of the adjacent bones are then divided by a narrow-bladed knife inserted in the interosseous spaces with the edge upwards. The dorsal carpo-metacarpal ligaments are next put on the stretch and divided with the point of the knife. The head of the bone is separated from the metacarpals on either side, the metacarpo-phalangeal articulation is opened, and the head of the bone seized with strong forceps and pulled forcibly backwards so as to allow the structures to be separated from the anterior surface of the bone right back to its base. The anterior carpo-metacarpal ligaments are then divided with the point of a narrow-bladed knife, the bone being twisted from side to side as this is done. There is no risk of injuring the structures in the palm in this method.

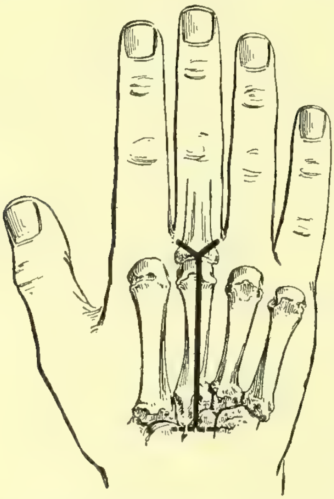

Fig. 233.—Amputation of a Metacarpal Bone alone. The diagram shows the best incision. The transverse dotted incision is not always required.

In cases of tumour of the metacarpal bone, the operation is rendered more difficult by the presence of the growth, and it is well, especially in cases of sarcoma, to take the neighbouring metacarpal on one or both sides, so as to avoid the risk of leaving disease behind. This is better than amputation of the hand. When more than one metacarpal bone is removed, however, it is well to take away at least one finger in order to preserve the full use of the hand as otherwise the fingers get crowded together as the wound contracts, and their usefulness is interfered with.

PARTIAL AMPUTATIONS OF THE HAND.

There are many partial amputations of the hand, for which it is almost impossible to give directions, as they may be varied widely to meet the circumstances of different cases. The essential points to bear in mind are that even the smallest portion of a hand is of great value to the patient, and its place can never be adequately filled by any artificial substitute ; consequently no considerations such as opening joints, or tendon sheaths, or partial removals of bone should be allowed to stand in the way of operations of this kind, provided always that asepsis can be maintained, and that the case be not septic to start with. The majority or the whole of the fingers may be removed, large portions of the metacarpal bones, and even of the carpus may be taken away ; but, so long as the smallest portion of the bony structures of the hand or wrist can be left behind, this should be done. The flaps, when possible, should be taken from the palmar aspect, as the structures there are more vascular than those on the dorsum, and are therefore less likely to slough. Moreover the flexor tendons can then be retained in the flap, and will help to increase the usefulness of the wrist. The flexor tendons should be seized when the flap is raised, cut as long as possible and stitched to the end of the stump, so that the power of flexion shall be preserved ; if this precaution be omitted, the object of the operation will be largely defeated, as the tendons will retract up their sheath and movement may be almost entirely lost, even though a considerable portion of the bony structures of the hand be left. The extensor tendons should be treated similarly.

AMPUTATION OF THE THUMB.

The operations for amputation of the thumb are practically the same as those for removal of the fingers, but the larger size of the bones will call for proportionately longer and larger flaps. What has been said as to the importance of leaving portions of the fingers behind applies still more strongly to the thumb. Every additional inch or fraction of an inch that can be preserved is of value to the patient, and in practice the operations necessary for the removal of the thumb will nearly always be some form of partial amputation rather than the typical operations described in text-books.

The terminal phalanx of the thumb may be removed in a manner exactly similar to that described for removal of the tip of the finger (see Fig. 234, *A*). *Amputation at the metacarpo-phalangeal joint* is best done by a racket-shaped incision which must be carried well down beyond the head of the metacarpal so as to insure plenty of covering for the large head of the bone. In order to avoid pressure on the scar and damage to the tendons, it is well to place the handle of the racket on the radial side of the thumb rather than over the dorsum ; the oval part of the racket should reach down to the middle of the first phalanx (see Fig. 234, *B*). The

scar lies to the outer side, and is therefore more out of the way of pressure than if the incision were made in a position similar to that for amputating the fingers. In this amputation the tendons should be sutured to the end of the stump (see p. 510). Farabeuf's method (see p. 512) also gives a good result.

When the first metacarpal bone is to be removed, it is important to preserve the short muscles of the thenar eminence intact, as they form a fleshy pad which will be of value in aiding the grasp of the hand after removal of the bone. The best incision for this purpose is racket-shaped, and commences just above the articulation of the metacarpal with the trapezium. It should be carried down on the dorsal surface to a point short of the head of the metacarpal, and then made to diverge laterally to the web, and encircle the thumb just above the level of the first knuckle-

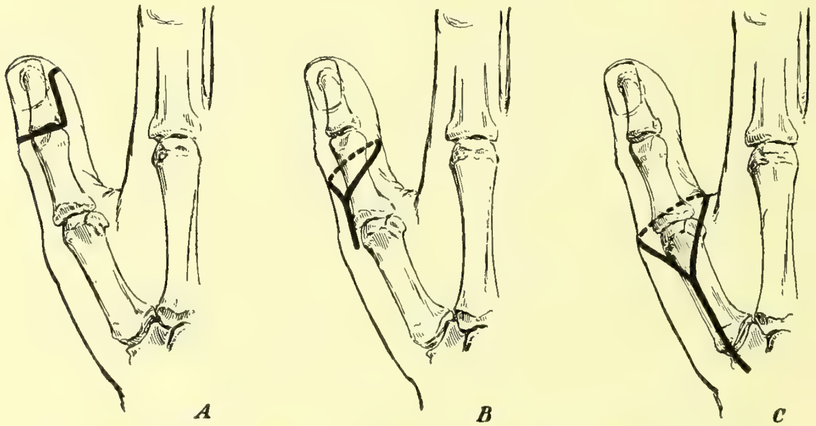

Fig. 234.—Amputations of the Thumb. *A*, Incisions for amputation of the terminal phalanx. *B*. Incision for amputation at the metacarpo-phalangeal joint. *C*, Incision for removal of the thumb along with its metacarpal bone.

joint[1] (see Fig. 234, *C*). The soft parts are dissected off the metacarpal bone, and the large thenar pad of muscles is left uninjured. The joint between the metacarpal bone and the trapezium is best opened from behind, the thumb being bent downwards into the palm, and the capsule thus rendered tense divided with the point of the knife. The internal lateral band may next be divided, great care being taken to keep the knife close to the bone. After that the external lateral band can be cut through, and then, by twisting the bone round, the anterior portion can be got at, and divided without any trouble ; the bleeding is comparatively slight. The radial artery should not be seen ; only some of its digital branches near the end of the flap require ligature.

[1] A good guide to the line that the encircling part of the racket should follow is what Farabeuf calls ' the opposition crease.' It is the definite crease that is always present when the thumb is slightly flexed and opposed to the index finger.

DISARTICULATION AT THE WRIST-JOINT.

This operation is rarely called for. It may be required for bad crushes of the hand and some cases of malignant disease. When amputation has to be done for tuberculous disease of the wrist, it should be performed through the forearm.

Disarticulation through the wrist-joint gives a very useful stump, because the forearm retains its power of pronation and supination, while the expanded lower ends of the bones of the forearm give a fair point of fixation for an artificial hand. The operation should therefore be done in preference to amputation through the forearm whenever it is practicable.

The shape of the flaps must be governed by the amount of skin available. The best flap is obtained from the palm, but this is not always

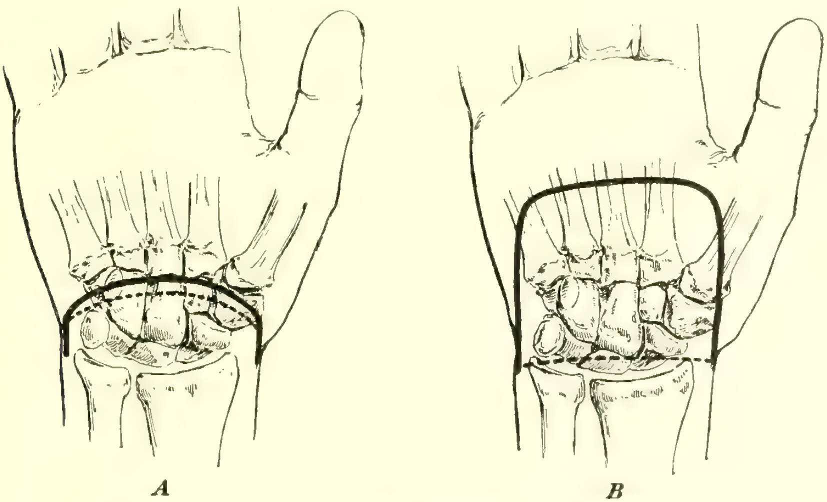

FIG. 235.—AMPUTATIONS THROUGH THE WRIST-JOINT. *A*, The modified circular method. *B*, Amputation by a long palmar flap. The thick lines show the palmar, the dotted ones the dorsal incisions.

available. An excellent result is obtained by means of the modified circular method, with equal dorsal and palmar flaps. When the tissues in the palm are destroyed, a single dorsal flap may have to be employed. No portion of the bones of the forearm should ever be removed unless it is absolutely necessary ; even the styloid processes of the radius and ulna should be preserved. Above all things it is necessary not to interfere with the radio-ulnar articulation.

Modified Circular Method.—In doing the modified circular operation comparatively short flaps will suffice, but these must extend a little lower upon the radial than upon the ulnar side, so as to compensate for the lower position of the styloid process of the radius. The following are the steps of the amputation, which will most usually be performed under

the circumstances in which this operation is called for : The surgeon places his left thumb and index finger upon the styloid processes. The forearm should be horizontal, at right angles to the trunk, and fully supinated ; both flaps should be cut from without inwards, and the palmar flap should be dissected up first. The pisiform bone should be raised with the palmar flap and dissected out afterwards. The incision commences at the tip of one styloid process, curves downwards along that border of the hand for about an inch, and is then carried across the palm to a point an inch below the opposite styloid process whence it runs upwards to the tip of that structure. A similar incision is carried across the back of the wrist ; the anterior or palmar flap should be a little longer than the dorsal one (see Fig. 235, *A*). The flaps are dissected up, the wrist-joint is opened immediately below one of the styloid processes and the hand is disarticulated. When the flaps are sutured, the incision lies over the lower end of the bones.

By a Long Palmar Flap.—When the tissues in the palm are intact and a longer palmar flap can be made, little or no dorsal flap will be required. This long palmar flap should be broad and not pointed. On the left side, the incision commences on the outer aspect of the styloid process of the radius, runs downwards along the outer side of the thumb to a little above the transverse crease of the palm, then transversely across the palm, and finally along the ulnar border of the hand to the tip of the ulnar styloid process (see Fig. 235, *B*). ; on the right side the incision will run in the reverse direction.

All the soft parts are turned up from the front of the hand down to the flexor tendons. The pisiform bone is raised in the flap. The two extremities of the palmar incision are then joined across the back of the wrist by an incision with a slight convexity downwards. This short skin flap is turned back, and the wrist-joint is opened by dividing one of the lateral ligaments ; the wrist-joint is fully flexed, and the posterior and lateral ligaments are then divided. The hand is removed by cutting downwards through the remaining ligaments and the flexor tendons, the hand being brought nearly into line with the forearm meanwhile, and the palmar flap being folded back and carefully kept out of the way by an assistant. During the second half of the operation the surgeon grasps the hand in his left hand and manipulates it in the desired directions. The palmar flap when sutured in position forms a fleshy and sensitive pad covering the ends of the bones of the forearm.

A drainage tube is generally required. The limb should be placed upon an internal rectangular splint with the forearm midway between pronation and supination. The splints and dressings may be left off in a fortnight.

AMPUTATION THROUGH THE FOREARM.

This is the amputation most commonly required for tuberculous disease of the wrist-joint, as it is rarely advisable to amputate through the joint itself and then saw off or gouge out the diseased areas in the lower end of the radius.

Modified Circular Method.—The best amputation is the modified circular form with equal anterior and posterior flaps. The scar lies directly over the end of the bones, which is the seat of least pressure, because the pressure exerted by an artificial limb upon the stump must necessarily fall upon either its anterior or its posterior aspect, and not upon the end of it, as is the case in the lower extremity. A further advantage of the modified circular operation is that the bones may be divided on a lower level than in any other operation. The flaps seldom have to be more than an inch and a half long, and thus the amputation can be performed close to the seat of disease, and yet sufficient covering for the bones can be obtained. This gives the patient the longest possible stump—a point of importance in the adaptation of an artificial limb. In some cases of injury it may be possible, by employing either a long anterior or a long posterior flap or irregular flaps, to divide the bone on a lower level than would be necessary if equal antero-posterior flaps were made. If this be the case the latter method should be abandoned in order to secure a longer stump.

Fig. 236.—Modified Circular Amputation through the Forearm. The flaps are antero-posterior and of equal length. The dotted line marks the point of section of the bones.

The limb should be abducted to a right angle with the trunk, held horizontally and fully supinated, and the surgeon, standing to the patient's right of the limb to be operated upon, marks the proposed point of division of the bones by placing the left forefinger and thumb upon them, one on either side of the limb. The knife is then entered about half an inch below one of these points, and is made to trace a short anterior flap terminating at a corresponding point on the opposite side. A similar posterior flap is then marked out (see Fig. 236). The length of the two flaps combined should be equal to slightly more than the antero-posterior diameter of the limb at the point at which the bones are to be divided, the additional length being required to allow for retraction of the flap. These flaps are dissected up to just beyond the level of their bases, and then the muscles are divided by a series of circular sweeps, and the periosteum is divided on the same level as the muscles, and peeled up by a raspatory to the point at which the saw is to be applied. If the amputation

be performed in the lower third it will be easier to divide the muscles and tendons by transfixion, and some care will be required to insinuate the point of the knife between the deeper tendons and the bones. In sawing the bones care must be taken to avoid splintering, and they should therefore be held quite horizontally, and the saw made to cut each bone to the same depth. When the division is nearly complete, the section of the radius should be finished off first, as it is the more movable bone and the ulna can be steadied better. The vessels requiring ligature are the radial, the ulnar, and the interosseous arteries.

After the vessels have been secured, the tube of periosteum is pulled down over the ends of the bones and the wound is stitched up, a small drainage tube being inserted at the dependent angle. The object of peeling up the periosteum is to guard against fusion of the cut ends of the bones, which would involve loss of pronation and supination.

The arm is placed upon an internal rectangular splint, with the forearm midway between pronation and supination. After about ten days the stitches may be taken out and the splint left off. In all cases the limb should be put up in the above position, so that, should fusion of the ends of the bones occur, the limb is in the most advantageous position for the application of an artificial substitute.

DISARTICULATION THROUGH THE ELBOW-JOINT.

This is not nearly so often done as is amputation above or below the articulation ; chiefly because the large size of the lower end of the humerus necessitates long flaps, and therefore the operation can only be done when the soft parts at the disposal of the surgeon are comparatively abundant. It should, however, be performed in preference to amputation through the lower third of the humerus whenever possible, as the increased length of the stump is of advantage, and the expanded end of the bone gives a better point of support for an artificial limb. The operation is usually done for a tumour affecting one or both of the bones of the forearm and sometimes for crushes of the latter ; it will be rarely suitable for elbow-joint disease.

In many cases it is found necessary to make irregular flaps, but, when possible, it is best to make a long antero-internal and a short postero-external flap. In providing a covering for the lower end of the humerus it is important to bear in mind the large size and irregular shape of the bone, and also the exact position of the elbow-joint. It is hardly necessary to remark that the level of the latter does not correspond to the tip of the olecranon. The best guide is the head of the radius, the position of which is found by placing the thumb immediately beneath the external condyle and pronating and supinating the forearm. The upper limit of the radial head usually lies about half an inch below the most prominent part of the condyle, and may be taken as a good guide to the level of the joint.

By a Large Antero-internal Flap.—An elastic bandage is placed around the upper third of the arm, the elbow is flexed to an angle of 135°, and the antero-internal flap marked out. The incision commences at the centre of the bend of the elbow, and is carried down parallel to the long axis of the humerus for about three inches. With the arm at the angle above mentioned, the incision should meet the inner border of the forearm at about this point. It is then curved backwards and upwards to the base of the olecranon. After this flap has been marked out, a somewhat similar one, but only about an inch in length (see Fig. 237), is cut from the external surface.

When the flaps are retracted, the soft structures are taken up right down to the bone. Disarticulation is performed by forcibly flexing the elbow, cutting through the triceps at its attachment to the olecranon, and then dividing first the lateral and then the anterior ligaments. It is recommended by some authors that the base of the olecranon should be sawn through and left *in situ*, so as to preserve the attachment of the triceps. This, however, is of no real advantage.

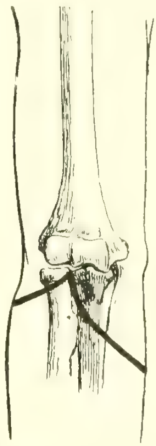

Fig. 237.—Amputation through the Elbow Joint by a Long Internal Flap. The incision for the large internal flap is carried up to a corresponding point behind the joint. The relative length of the flaps may be varied to suit the circumstances of the case.

The large antero-internal flap will fold completely over the lower end of the humerus, and cover the prominent internal condyle. The vessels requiring ligature are the brachial itself, which should be secured before the Esmarch's bandage is taken off, and a few smaller vessels, such as the terminations of the superior and inferior profunda arteries and some of the anastomotic branches about the joint. A drainage tube should be inserted at the upper angle of the flaps behind, and the arm placed in a trough of Gooch's splint upon a pillow.

Various other flaps may be employed to cover in the lower end of the humerus, according to the circumstances of the case with which the surgeon has to deal. A large variety of operations have been described, such as amputation by a long anterior and a short posterior flap, by an external skin flap, by the circular method, and so on. It is probable that in the majority of cases the operation that we have described may not be feasible owing to the lack of sufficient soft parts, and in these the modified circular method (see p. 486) will probably have to be adopted. The obliquity of the condyles must be remembered; the flaps must extend further downwards on the inner than on the outer side.

AMPUTATION THROUGH THE UPPER ARM.

Amputation in this situation may be required for extensive injuries to the forearm, for tumour, or for tuberculous or other disease of the elbow-joint not suitable for excision. It is important to retain as much of the humerus as possible, so as to give sufficient leverage for an artificial limb, and, therefore, the section of the bone must be made as low down as is consistent with entire removal of the disease.

Modified Circular Method.—This is practically the operation of choice for amputation in the upper arm, since in it there is the least sacrifice of bone. The exact position of the flaps, whether antero-posterior, lateral or irregular, is not a matter of great consequence ; probably antero-posterior ones are best on the whole. The old operations by transfixion and the formation of long flaps necessitate the removal of an undue length of bone, and have therefore nothing whatever to recommend them. For a description of the modified circular method see p. 486.

In amputating through the upper arm the vessels requiring ligature are few. The brachial artery, its superior and inferior profunda branches, with possibly a few muscular twigs, are all that will give any trouble. The best means for preventing hæmorrhage in amputations high up in the arm will be found on p. 494.

DISARTICULATION AT THE SHOULDER-JOINT.

A large variety of methods of amputating through the shoulder-joint have been described, the most popular until recently being that by means of the deltoid flap. Here again, however, irregular operations of all kinds will be the most useful in actual practice, as the operation is usually called for in cases where it is difficult to obtain flaps by the orthodox methods. When a set operation is possible, probably the best and most satisfactory in its results is Spence's operation (see Fig. 238, *A*). Spence describes his operation as follows :—

Spence's Operation.—'Supposing the right arm to be the subject of amputation. The arm being slightly abducted and the head of the humerus rotated outwards, with a broad straight bistoury, I cut down upon the inner aspect of the head of the humerus, immediately external to the coracoid process, and carry the incision down through the clavicular fibres of the deltoid and pectoralis major muscles till I reach the humeral attachment of the latter muscle which I divide. I then with a gentle curve carry my incision across and fairly through the lower fibres of the deltoid towards, but not through the posterior border of the axilla. Unless the textures be much torn, I next mark out the line of the lower part of the inner section by carrying an incision through *the skin and fat only* from the point where my straight incision terminated across the inside of the arm to meet the incision at the outer part. This insures accuracy

in the line of union, but is not essential. If the fibres of the deltoid have been thoroughly divided in the line of incision, the flap so marked out along with the posterior circumflex trunk, which enters its deep surface, can be easily separated from the bone and joint, and drawn upwards and backwards so as to expose the head and the tuberosities by the point of the finger without further use of the knife. The tendinous insertions of the capsular muscles, the long head of the biceps and the capsule are next divided by cutting directly on the tuberosities and head of the bone, and the broad sub-scapular tendon especially being very freely exposed by the incision, can be much more readily and completely divided than in the double-flap method. By keeping the edge of the posterior flap out

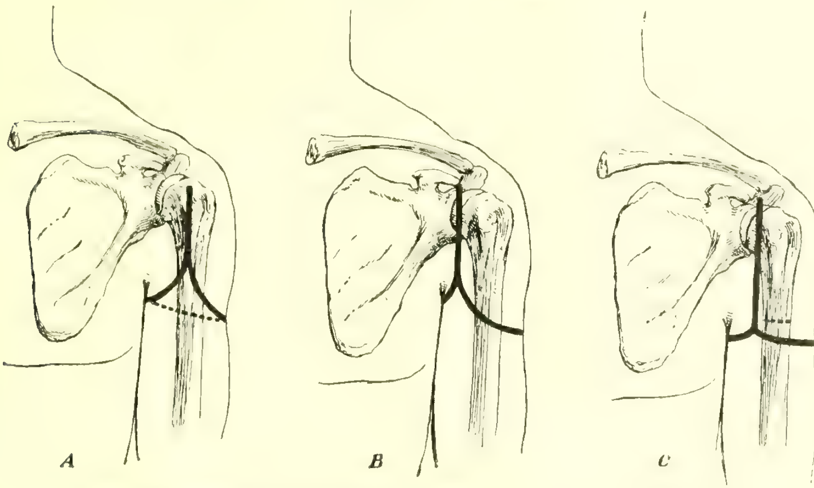

FIG. 238.—METHODS OF AMPUTATING AT THE SHOULDER-JOINT. *A*, Spence's amputation. *B*, Amputation by a long deltoid flap. The incision for this flap is carried up to a corresponding point on the back of the shoulder. *C*, Furneaux Jordan's method applied to the shoulder. The transverse incision is a circular amputation with the edges just rounded off where the vertical incision meets it. The dotted line denotes the point of section of the bone. The upper end of the latter is subsequently enucleated.

of the way by a broad copper spatula or the fingers of an assistant, and taking care to keep the edge of the knife close to the bone, as in excision, the trunk of the posterior circumflex is protected. The only vessel which bleeds is the anterior circumflex divided in the first incision, and, if necessary, a pair of catch forceps may be placed on it at once. With regard to the axillary vessels they can either be compressed by an assistant before completing the division of the soft parts on the axillary aspect, or to avoid all risk the axillary artery may be exposed, tied and divided between two ligatures so as to allow it to retract before dividing the other textures. In cases where the limb is very muscular I dissect up the skin flap from the deltoid at the lower part and then divide the muscular fibres higher up by a second incision, so as to avoid redundancy of muscular

tissue. The advantages I claim for this plan are, first, the fulness and better form of the stump left after healing ; second, the posterior circumflex artery is not divided except in its small terminal branches in front, whereas both in the large deltoid flap and the double methods the trunk of this vessel is divided in the early stages of the operation, and retracting often gives rise to embarrassing hæmorrhage. In the case of the deltoid single-flap method the vitality of the flap must be seriously compromised, as it depends chiefly on that vessel for its arterial supply. Third, the great ease with which disarticulation can be accomplished.'

The above operation will chiefly be called for in cases of tumour of the humerus or disease of the upper end, or for tuberculous disease of the shoulder-joint itself. In the latter case the operation must be extended by removing the glenoid cavity, which can be cut away with bone pliers after the limb has been removed ; in addition, all the synovial membrane must be dissected out, as well as the bursa beneath the deltoid if that should happen to be affected.

Operation by a Deltoid Flap.—In cases of tumour occupying the head of the humerus, Spence's operation is not applicable, and in these either the deltoid flap method or some more irregular form of amputation based upon it will be the best (see Fig. 238, *B*).

Incision.—An incision is made from the tip of the coracoid process vertically downwards as far as the level of the insertion of the deltoid, and from this point it sweeps across the front and outer aspects of the arm with its convexity downwards until it reaches a corresponding point behind, whence it is carried vertically upwards to the root of the acromion. When this flap is dissected up, it should consist of skin, subcutaneous tissue and deep fascia for the first inch or two ; then the deltoid should be raised as the flap is further dissected up. The axillary vessels should be exposed in the incision before the flap is dissected up ; they should be divided between two ligatures, the upper end being stripped up and kept out of the way during the later stages of the operation.

After the flap has been raised, the ends of the incision are united by another on the inner side of the arm which forms a flap of sufficient length with its convexity downwards. The length of this will vary inversely with that of the deltoid flap. When it is possible to cut the latter the full length the internal flap need only be short ; a longer one will be called for, if the deltoid flap has to be made shorter than usual.

Disarticulation.—The deltoid flap is held well up out of the way and the external rotator muscles are divided close to their insertion into the great tuberosity, the capsule is opened and the knife is slipped behind the head of the bone, and made to divide the tissues forming the deeper part of the internal flap.

Removal of the Joint entire.—When the amputation is done for malignant disease of the upper end of the humerus, it is as well to remove the glenoid cavity and the whole of the capsule of the joint, lest the disease should

have infected this structure ; in these cases the deltoid should not be raised with the flap, and the division of the rotators should be effected at some distance from the joint. Then, if the condition of the parts permits, the neck of the glenoid cavity should be cleared without opening the capsule and detached with powerful cutting pliers or a chisel, and the whole of the glenoid cavity with the capsule of the joint intact should be removed in one piece.

Operation by Lateral Flaps.—The incisions for this operation commence just below and external to the tip of the coracoid process. They run down, at first vertically for about four inches, and then diverge in a curved form with the convexity downwards across the inner and outer aspects of the limb, to meet at a point over the posterior fold of the axilla opposite their commencement. The flaps should be of equal length; it is easy to secure the axillary vessels in the inner flap as the incision is being deepened, and thus no compression of the vessels is required.

Furneaux Jordan's Method.—This amputation is similar to Furneaux Jordan's amputation at the hip-joint and may be applicable to cases of long-standing bone disease, especially extensive osteo-myelitis or necrosis. The arm is amputated by the modified circular method (see p. 486) at about the level of the insertion of the deltoid, the flaps being made somewhat antero-external and postero-internal ; an incision is then carried vertically upwards upon the inner side of the arm from the junction of the flaps towards the tip of the coracoid process. This incision is deepened down to the bone, the periosteum is peeled off and the upper end of the bone is extracted (see Fig. 238, *C*).

In this operation a certain amount of new bone may form from the periosteum left behind ; if not, there will be a firm fibrous centre to the stump which should give useful support to an artificial limb.

The cases in which an operation of this kind will be called for are extremely few nowadays, as amputation for necrosis is of the greatest rarity. Even should it be necessary to open up the whole length of the bone in order to remove the sequestrum, this is preferable to amputation. Therefore, we are of opinion that Spence's method is the best when it can be done, and when it cannot the deltoid or lateral flap methods seem to offer the most satisfactory results.

REMOVAL OF THE ENTIRE UPPER EXTREMITY.

Indications.—It may be necessary to remove the entire upper extremity, that is to say, the upper limb together with the scapula. The cases calling for this severe operation are those of malignant disease of the upper end of the humerus involving the scapula, or malignant disease of the scapula, which has spread to the shoulder-joint or the soft parts in the region of the shoulder to such an extent that it is unsafe to leave the

arm behind. The operation has also been done for extensive recurrent cancer of the breast ; but when breast cancer has advanced so far as to necessitate an operation of this kind the case is hopeless, and operation does not offer the least prospect of prolonging life. There are several methods of doing the operation ; that described by Berger is, perhaps, the best.

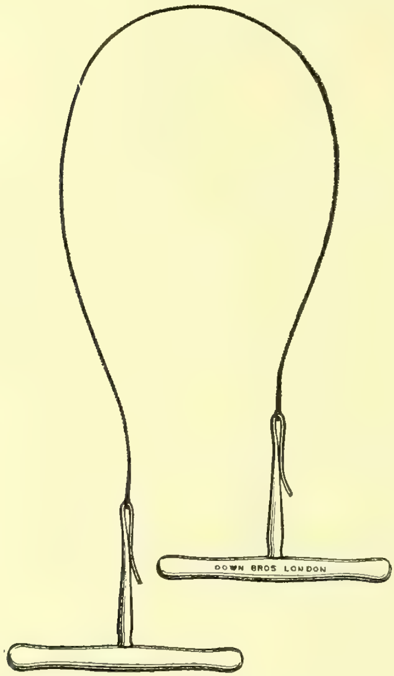

FIG. 239.—GIGLI'S SAW. The saw is a finely tempered wire with a low screw-thread round it. This is introduced by the special introducer shown in Fig. 240. The handles are then hooked on and the bone is rapidly divided. It is a most useful saw for many purposes, as its fineness enables it to be passed where others will not go.

Position.—The patient should be drawn as far as possible to the edge of the table, so that the shoulder on the affected side projects beyond its edge, and the thorax should be well raised by sandbags. The first step in the operation consists in dividing the clavicle and ligaturing the subclavian vessels.

Preliminary Ligature of the Subclavian Vessels.—An incision is made along the upper border of the clavicle down to the bone, from the outer edge of the sterno-mastoid to the outer end of the clavicle. The bone is carefully cleared below and divided at the junction of the two curves. The division may be effected with a saw or strong cutting pliers. We have found that the simplest and quickest plan is to use Gigli's wire saw (see Fig. 239). This can be passed round the bone by means of the instrument shown in Fig. 240, and the division can thus

FIG. 240.—STILES'S INTRODUCER FOR GIGLI'S SAW. The instrument is passed round the bone like an aneurysm needle and the wire saw is then hooked into its eye and drawn into place as the instrument is withdrawn.

be practised in a few minutes with perfect safety as the bone requires little or no clearing, the instrument being passed like an aneurysm needle. The outer end of the clavicle is pulled forcibly upwards with lion forceps, whilst the tissues beneath it are stripped off. The outer end of the bone can then be disarticulated from the scapula or cut across with

cutting pliers just short of the articulation, and removed so as to expose the axillary vessels and the brachial plexus, which are covered by the subclavius muscle. The artery and vein are identified as they lie over the first rib, and both vessels are tied separately in two places and divided between the ligatures. It is well to ligature and divide the artery before the vein, and to raise the extremity after division of the artery, so as to allow the blood to flow back through the vein and thus preserve what would otherwise be lost. The vein, moreover, will then cease to be distended with blood and will therefore be more easily manipulated, and not so likely to get torn. The vein, however, may overlap the artery to such an extent that it will be necessary to tie it first.

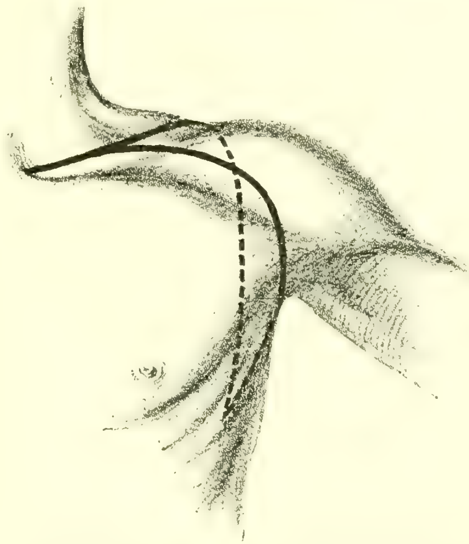

Fig. 241.—Incisions for Removal of the Entire Upper Extremity.—The thick line shows the incision on the anterior aspect of the trunk, the dotted one that on the posterior.

The divided ends of both vessels are separated upwards and downwards by the handle of the knife, and then the brachial plexus should also be divided and the lower ends stripped downwards. Before completing this stage of the operation, it is well to insert the handle of the knife or the finger beneath the deep fascia of the neck and to separate the tissues to a moderate extent, lifting them up and searching for, and, if possible, ligaturing the supra-scapular and the posterior scapular arteries. The former is usually readily found and can be ligatured at once; the latter may also be identified, but it is not worth while spending much time in the search.

Raising the Anterior Flap.—The next step is to mark out the incisions for the removal of the extremity; these form an elliptical incision including the shoulder and part of the scapula. An assistant abducts the arm to a right angle and pulls the trunk well over, so that the shoulder projects free of the table, and then the front portion of the incision is marked out. The knife should be carried from the centre of the incision over the clavicle downwards with an outward curve over the coracoid process to the junction of the anterior fold of the axilla with the arm. It is then carried transversely across the axilla to its posterior fold and thence to

the inferior angle of the scapula (see Fig. 241); the assistant, meanwhile, manipulates the arm so as to facilitate the fashioning of the flap.

This incision is now deepened by dividing the muscles close to the humerus, and a flap of skin and muscle is turned inwards so as to expose the contents of the axilla, which consist of the vessels already divided above, and of fat and glands, which should be stripped down in one mass so that they can be removed along with the upper extremity. The arm and shoulder are next rotated outwards so as to expose the ventral aspect of the scapula, and the serratus magnus and the rhomboids are divided near their insertion into the posterior border of the scapula; the levator anguli scapulæ is similarly treated. The posterior scapular artery, if not already secured, will be divided here and may be clamped.

Raising the Posterior Flap.—The patient is now turned over upon the sound side, the arm pulled forcibly across the chest by an assistant, and the posterior incision, which runs from the extreme outer end of the incision over the clavicle to the inferior angle of the scapula by the shortest route, is marked out. As this incision is deepened and the flap is turned back, the few remaining muscular fibres are divided, and the extremity is removed.

Although the main vessels have been already tied, numerous small points will need to be clamped and tied. The greatest difficulty is met with at the posterior border of the scapula when the posterior scapular artery has not been secured in the first stage of the operation, and attention should be directed to this region after the extremity has been removed. The best plan is to pack the whole raw area immediately the extremity has been severed, and to have pressure exerted by an assistant; the packing is then removed gradually and the vessels picked up. Before the wound is stitched up, any diseased glands left behind should be removed. A large drainage tube is inserted at the lower angle of the wound, and the dressings are fixed in position by a broad sheet of muslin passing around the trunk with an aperture through which the sound arm is passed. The drainage tube may be left out about the fourth day, and the stitches taken out about the tenth.

REMOVAL OF THE SCAPULA ALONE.

It may sometimes be possible to remove the scapula alone and leave the extremity intact, and thus retain a useful arm. In some rare cases, partial removal of the scapula may be practised, but, as the operation is usually done for malignant tumours of the bone, it is, as a rule, not advisable to leave behind any portion, except possibly part of the acromion. This structure is of importance, as its retention materially increases the usefulness of the limb by facilitating the attachment of an artificial limb.

Removal of the scapula alone is more difficult than removal of the entire upper extremity, the points of greatest difficulty being the severing

of the muscles attached to the coracoid process and the free hæmorrhage which may follow division of the sub-scapular artery or its dorsalis scapulæ branch.

In order to overcome these difficulties, which are most likely to be met with when there is a large growth which displaces the parts considerably, we have recommended [1] that the operation should be commenced by a separate incision into the axilla through which the muscles are detached from the coracoid process and the sub-scapular artery is tied. This procedure has the further advantage that the vessels and nerves can be separated from all connection with the scapula or the tumour, and kept out of the way by an assistant throughout the remainder of the operation; if they should be involved in the tumour, the operation will have to be converted into a Berger's operation and the whole upper extremity removed.

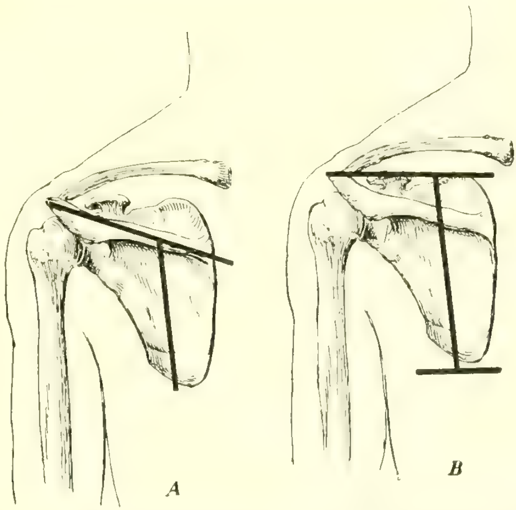

Fig. 242.—Amputation of the Scapula. A, The most suitable incisions when the deltoid and latissimus dorsi muscles are not involved in the growth. B, Incisions useful when these muscles are so involved. The vertical incision in these cases often has to be made an elliptical one. [The preliminary axillary incision recommended in the text is not shown.]

Operation. — *Preliminary Incision.*—An incision similar in direction to that for ligature of the third part of the axillary artery (see p. 216), but about six inches long, is made along the line of the axillary artery from its junction with the brachial, so that the axilla is opened up throughout its whole extent. The anterior fold of the axilla is raised so as to expose the coracoid process, and the pectoralis minor, the coraco-brachialis, and the short head of the biceps are divided close to the bone. This exposes the axillary artery so that its sub-scapular branch can be identified and ligatured. The large vessels and nerves are then raised by the hand passed beneath them and separated from any adhesion to the growth; a broad copper spatula may be passed between them and it, and left in position during the rest of the operation.

Incision for Flaps.—The patient is now turned over almost upon the face, and incisions are made for the removal of the scapula. When the

[1] See *Clinical Society's Transactions*, vol. xxviii. p. 284.

growth does not involve the muscles over the back of the bone, the incision may begin over the acromion process and run downwards and backwards along the spine of the scapula to about a couple of inches beyond the vertebral border. From the centre of this incision a second is made running vertically down to the inferior angle (see Fig. 242, *A*). When, however, the tumour involves the muscles upon the back of the bone this incision will have to be modified. In many cases a portion of the skin over the tumour will have to be included in an oval incision and removed. In other cases an I-shaped incision gives the best result. This incision, commencing at the acromion process, runs along the upper border of the scapula to its vertebral angle; from the centre of this a vertical incision is carried down to the inferior angle, and at the lower end of this a second transverse incision is made. This gives two skin flaps which are turned outwards and inwards (see Fig. 242, *B*).

The first incision described, however, should always be chosen if it can be safely employed, as the attachments of the trapezius and the deltoid can afterwards be stitched together and the movements of the arm may be thus more satisfactorily preserved. The incision is deepened, and the attachments of the trapezius to the upper border of the spine of the scapula and of the deltoid to its lower edge are divided. The flaps with the muscles are turned aside. An assistant now pulls the arm forcibly forwards and downwards and thus puts the rhomboidei on the stretch, so that they can be divided. The finger is then passed beneath the posterior border of the bone, and the serratus magnus is pulled forward and cut through. If the acromion is to be left behind, it should now be snipped across with bone forceps, or if it is to be taken away, it should be disarticulated from the clavicle. The teres major should next be divided, and after that the rotator muscles of the humerus are cut across close to the scapula if they are free of the disease, or close to the humerus if they are involved in it. The scapula is now free except for the attachment of the levator anguli scapulæ, the omo-hyoid, and the supra-scapular vessels and nerves. When they are divided, disarticulation at the shoulder-joint is performed and there is nothing to prevent the removal of the bone, as the structures attached to the coracoid process have already been divided.

The arteries requiring ligature are the posterior and supra-scapular; these can often be clamped before division. The posterior scapular is seen immediately after the division of the rhomboidei and levator anguli scapulæ, whilst the supra-scapular is not divided until just before the bone is removed, when it can be easily seen above the supra-scapular notch. The sub-scapular has been already secured through the preliminary anterior incision.

After the bleeding has been arrested, the trapezius and the deltoid muscles which have been detached from the spine of the scapula (when the condition of the parts allows this to be done) are sewn together by

catgut in the manner recommended for suture of muscles (see p. 64). The union of these two muscles is of great importance to the subsequent usefulness of the arm. If the rotators of the humerus have been divided close to the scapula, they may be stitched to the serratus magnus in the same manner, but this is not of so much consequence, because they readily form adhesions to the scar, which gives them a more or less fixed point to act from.

After-treatment.—A large drainage tube should be inserted at the lower angle of the wound, and moderately firm pressure is applied over the flaps to prevent accumulation beneath them. The arm must be pushed up against the acromion and supported by a suitable sling, a pad being placed in the axilla to throw the head of the bone away from the side. This support to the arm must be continued for three or four months after the wound has healed, so as to allow the parts to become consolidated before the weight of the limb is allowed to tell upon them. Passive movement of the upper extremity should be begun in about three weeks, when the patient should also attempt active movement.

Results.—The results obtained are extremely good, particularly when the acromion process is left. As a rule all underhand movements are perfect and the most complicated manipulations can be performed; overhand movement, however, is practically never regained.

CHAPTER XXXI.

AMPUTATIONS IN THE LOWER EXTREMITY.

AMPUTATIONS OF THE TOES.

GENERAL CONSIDERATIONS.—These operations are called for under circumstances similar to those demanding amputation of the fingers, but whereas in the fingers it is important to preserve all the bone that can be retained safely, in the toes it is best to remove the entire phalanx instead of leaving part behind. Except in the case of the great toe, a portion of a toe is of no use to the patient. On the contrary it is likely to become drawn up so that it presses against the boot and gives rise to pain and ulceration. As long as the heads of the metatarsal bones are left and the tread of the foot is unimpaired, the loss of one or indeed several toes is a matter of no great importance.

In the case of the great toe, however, the contrary is the case. Through it a great portion of the weight of the body is transmitted to the ground, and it is therefore important to save even a small portion of the first phalanx. But if this be done, it is essential that the tendons should be stitched to the periosteum or the edge of the tendon sheaths in the manner described for removal of portions of the phalanges of the fingers (see p. 510).

The skin of the toes in the region of the nails is difficult to disinfect thoroughly, and special care will have to be taken in the purification in all these operations. It is a good plan to keep on a wet gauze compress of a 1 in 2000 corrosive sublimate or 1 in 40 carbolic acid solution, covered up in mackintosh or jaconet for at least twelve hours before the operation.

The methods of amputation for the toes are identical with those for the fingers (see p. 506). The incisions are illustrated in Fig. 243, *A*. The metatarso-phalangeal joint is relatively higher above the web than the

metacarpo-phalangeal joint, and the articulation is not so easily made prominent by bending the toes as it is by bending the fingers.

REMOVAL OF THE METATARSAL BONES.

The metatarsal bone may be removed along with its corresponding toe in a manner similar to that employed for the hand, by prolonging the handle of the racket-shaped incision upwards over the dorsal surface of the metatarsal to just beyond its base (see Fig. 243, *B*). In both the great and little toes it is important to remove as little as possible of the metatarsal bone, because both of them play an important part in support-

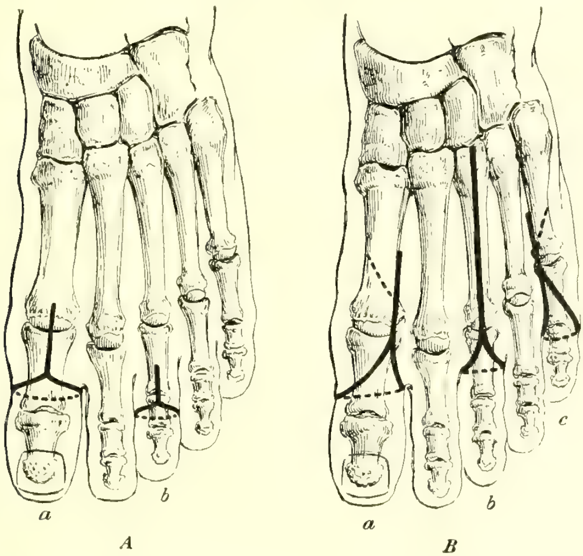

Fig 243.—Amputations of the Toes. *A*. Amputations of the phalanges; *a* is an amputation at the metatarso-phalangeal joint, *b* one through the first interphalangeal joint. *B*. Amputations of the toes along with the metatarsal bones; *a* and *c* are amputations of the great and little toes with the heads of the metatarsals respectively. As little of the bone is removed as possible. The dotted line shows the direction in which the bone is divided. *b* shows the removal of a toe with its entire metatarsal bone.

ing the weight of the body. It is also important to remember that no incisions should be carried into the sole of the foot, nor should they be placed either upon its inner or outer borders, as otherwise the resulting scar will be subject to pressure. For amputation of the first and fifth toes Farabeuf's method (see p. 512) gives excellent results.

AMPUTATIONS OF THE FOOT.

In actual practice it rarely that any set amputation of the foot can be performed with advantage to the patient. Just as in the hand, it is necessary to leave behind as much of the foot as possible, and therefore

irregular amputations will be far more frequently of use than the set operations described in the text-books on operative surgery.

GENERAL CONSIDERATIONS.—There are one or two practical points common to all operations on the foot, which it may be well to mention here. In selecting flaps, the skin from the plantar surface will form the best material, and should be utilised if possible. No scar should be allowed on the plantar surface or upon either side of the foot, as it would be exposed to considerable pressure ; it should lie either over the end of the stump, to which there is no particular objection, or somewhat on the dorsal surface. If possible it should lie just over the dorsal aspect of the end of the stump. If it comes too high up upon the instep it may be subjected to friction from the boot. So great is the value of even a small portion of the foot—even though only enough be retained to preserve the action of the ankle-joint—that it is allowable to make flaps that are too short to meet accurately, and to skin-graft the gaps left between them. This, however, should only be done when the interval so grafted lies upon the dorsum, for a skin-grafted patch upon the sole would interfere considerably with the patient's walking.

Several set operations are described for amputation of the foot, but as they are practically never performed except in the dissecting-room we shall not go into them in detail.

Lisfranc's Operation.—This is a disarticulation through the tarso-metatarsal joints, and the stump is covered in by a long plantar flap, which is made to fold upwards over the end of the tarsus. On account of the difficulties experienced in disarticulating the base of the second metatarsal bone, this operation was modified by Hey, who sawed across the base of the bone.

It can be readily understood that in cases requiring amputation in this situation it is extremely seldom that a plantar flap of the requisite length will be obtainable. Should the case be one of severe crush of the toes, some much more partial operation will probably suffice ; should the damage involve the metatarsal bones, it is practically certain that the tissues in the sole of the foot will be as seriously injured as those upon the dorsum. In cases of gangrene also, amputation so near to the gangrenous part is out of the question, and, should the case be one of tumour, the amputation will, of course, have to be performed at a higher level. Therefore, the operation is practically only performed upon the dead subject.

Chopart's Amputation.—Chopart's amputation also is practically only performed upon the dead subject and in examinations. The operation is a disarticulation at the medio-tarsal joint, the covering being obtained by a long plantar flap which extends forwards to the balls of the toes. In disease of the tarsus this operation is inadvisable, because the disease is sure to extend to one of the articular surfaces of the astragalus or the os calcis, and it is not easy to remove all the diseased synovial

membrane. In cases of injury a long plantar flap will be unattainable, and in cases of gangrene the front part of the plantar surface will probably be involved in the gangrenous process. Apart from these drawbacks to the operation itself, the after-results are not good. The tendo Achillis draws up the heel and therefore depresses the front of the stump. Even if tenotomy be performed at the time of the operation, this tilting of the stump recurs at a later period when the tendon has united. The result is that the patient bears pressure upon the end of the stump and there is considerable pain and ulceration. In our opinion these operations might with great advantage be left out of text-books on operative surgery.

SUB-ASTRAGALOID AMPUTATION.

In this valuable method the whole of the tarsus below the astragalus is removed, leaving the latter behind, with the ankle-joint unimpaired. The natural ankle-joint movement can thus be communicated to the artificial foot, and this is a great advantage. The best method of amputation is, perhaps, that recommended by Farabeuf, who makes a large internal plantar flap (see Figs. 244 and 245).

The foot should project well beyond the end of the table, the skin must be scrupulously purified, and the front part of the foot should be wrapped in gauze soaked in a 1 in 2000 sublimate solution, so that the hands of the assistant holding it will not be infected and, therefore, cannot endanger the wound. This precaution should be adopted for all amputations about the foot. A tourniquet should be applied to the thigh.

In operating upon the right foot the limb is rotated firmly inwards, and the incision commences about a finger's breadth below the tip of the external malleolus and runs forwards parallel to the outer border of the foot as far as the level of the tubercle of the fifth metatarsal bone. It then sweeps across the dorsum with a slight convexity downwards just in front of the articulation between the scaphoid and the cuneiform bones, as far as the tendon of the extensor proprius hallucis. From this point the incision is continued downwards across the inner border of the foot to the centre of the sole, and during this part of its course it has a marked convexity forward which reaches as far down as the central point of the inner border of the foot. From the centre of the sole the incision passes across to the outer border of the foot, sloping gradually back as it does so, until it passes on to the outer surface just behind the tuberosity of the fifth metatarsal bone. It now follows the outer border of the foot horizontally until the outer tuberosity of the os calcis is reached, when it passes upwards over the back of the heel to join the first part of the incision which has been prolonged horizontally backwards from the malleolus to the insertion of the tendo Achillis. While the last part of the incision is being made, the foot must be elevated and flexed

When marking out the incision in the left foot, the limb is rotated

inwards, and the incision is begun over the tendon of the extensor proprius hallucis and carried over the dorsum backwards and outwards to the outer edge of the tendo Achillis. Then the foot is raised and rotated outwards, and the knife traces out the remainder of the incision, beginning once more over the hallucis tendon and running thence over the sole and backwards and outwards to its outer border, and thence along the insertion of the tendo Achillis where it joins the first portion.

This incision is carried right down to the bone and the flap thus formed is dissected up, while the leg is rotated inwards and the foot held at right

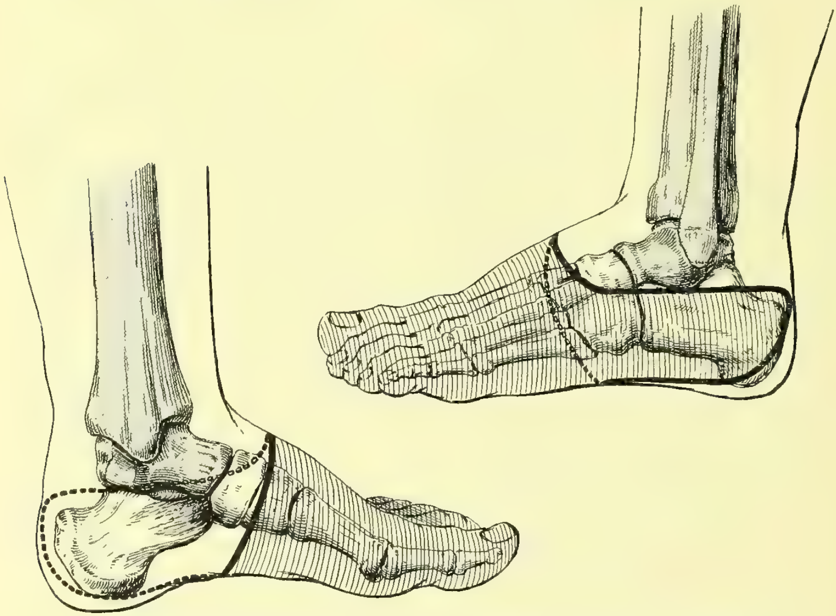

FIG. 244.—FARABEUF'S SUB-ASTRAGALOID AMPUTATION OF THE FOOT. The shaded portions of the foot are those removed. The deeply shaded bones, on the other hand, are those left behind. The thick continuous line is the incision on the side looked at, the interrupted one that on the opposite side.

angles to it with its outer surface uppermost. As the flap is raised, the articulations between the os calcis and the astragalus on the one hand, and the astragalus and the scaphoid on the other, are exposed. If the dorsal part of the flap be dissected well back and held out of the way, the joint between the astragalus and scaphoid can be opened, and then, by depressing and pulling the point of the foot inwards, the knife can be passed between the astragalus and the os calcis, and made to divide the strong interosseous ligament. The insertion of the tendo Achillis is next divided, and the soft structures are detached from the os calcis, in doing which great care must be taken to keep the edge of the knife close to the bone for fear of injuring the flap. The anterior and posterior tibial nerves should be pulled out and cut off as short as possible.

When the flaps are brought together, the line of union is on the anterior and outer aspects of the stump, and the patient walks on the thick skin normally forming part of the sole. A drainage tube should be inserted at the posterior angle of the wound for three days.

In three or four weeks the stump should be firm enough to allow the

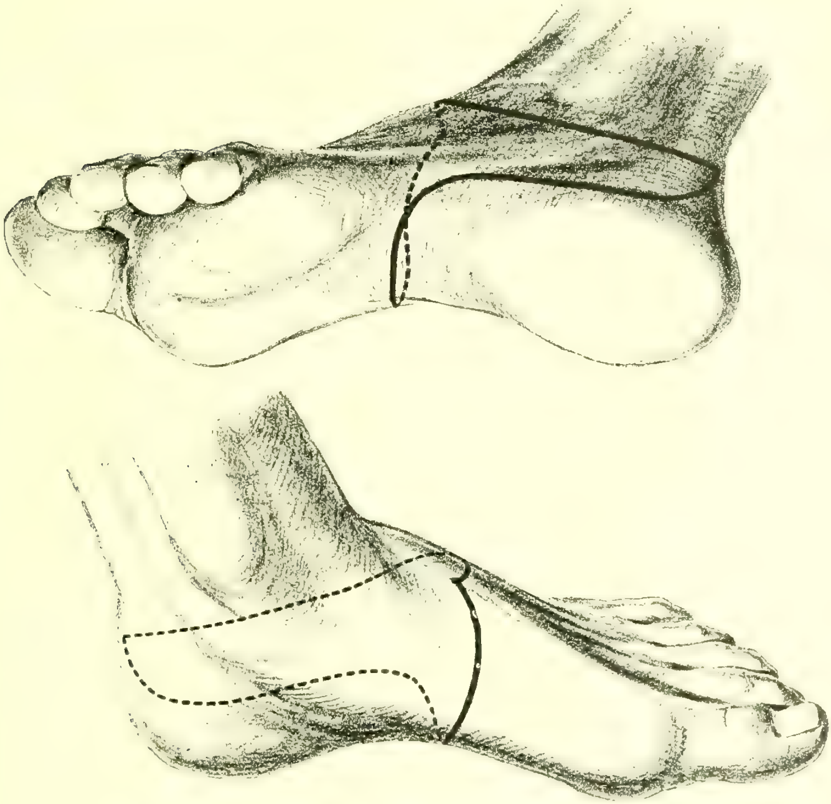

FIG. 245.—FARABEUF'S SUB-ASTRAGALOID AMPUTATION OF THE FOOT. Lines of incision seen in *A* from the inner, in *B* from the outer side of the foot. In each case the dotted line shows the line of incision on the opposite side of the foot to that from which the drawing is made.

patient to bear weight upon it. In the interval, the ankle-joint should be exercised passively, so as to prevent adhesions.

SYME'S AMPUTATION.

This is one of the most useful amputations about the foot and is applicable to a large number of cases. It may be employed for gangrene which is limited to the toes, so long as the tibial arteries are unobstructed ;

it is useful for many cases of tumour of the foot, and for tuberculous disease and severe crushes of the tarsus. It has also been employed for tuberculous disease of the ankle-joint itself, but it is very difficult to remove the disease thoroughly without damaging the vitality of the flap, and it cannot therefore be recommended for these cases. Syme's amputation provides an excellent stump capable of bearing the entire body weight, and easily fitted with an artificial limb.

The operation is performed as follows: The preliminary measures for disinfection, recommended on p. 535, are attended to, and a tourniquet is applied around the lower third of the thigh. The patient lies upon his back with the foot projecting well over the end of the table and held by

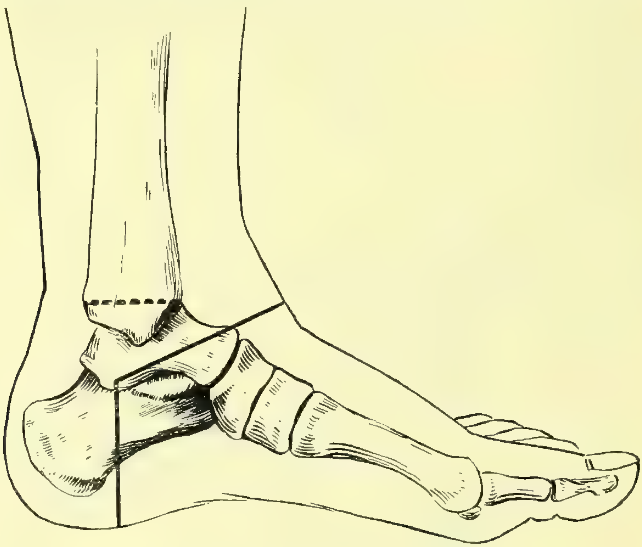

Fig. 246.—Syme's Amputation. The thick lines denote the skin incisions which pass direct from one side to a corresponding point on the other. The dotted line is the level of the bone section when the joint is healthy; should there be disease of it, the section will be entirely above the articular cartilage.

an assistant strictly at right angles to the leg. The surgeon marks out the base of his flap by placing the thumb over the tip of the external malleolus and the forefinger half an inch below and a little behind the tip of the internal malleolus. These points are connected by an incision carried vertically down across the sole right down to the bone. It is important that this incision should run vertically downwards and transversely across the sole from one point to the other (see Fig. 246). Should it be made to slope at all forwards into the sole, great difficulty will be experienced during the later stages of the operation in dissecting back the flap. On the other hand, should it be made to slope backwards towards the point of the heel, the flap will probably be insufficient to cover the ends of the bones. This incision should be made

by a stout knife, often termed a 'Syme's' or a 'foot' knife (see Fig. 247) and the two original points are connected by an incision carried directly across the front of the ankle from one point to the other by the shortest route, so that there is no true dorsal flap.

The next step is to dissect up the heel flap from the os calcis. The assistant should raise the limb until it is on a convenient level for the surgeon, and should depress the toes so as to relax the structures over the heel while the flap is raised from the os calcis by pressing back the edge of the flap with the thumb of the left hand, and dissecting up everything down to the periosteum. As the flap is raised, the thumb pulls it back and prevents it from being damaged by the knife, the edge of which should be kept strictly in contact with the bone. The greatest difficulty is met with as the prominence of the heel is reached; at this point special care must be taken not to nick the posterior tibial artery on the inner side of the ankle, as such an accident would imperil the nutrition of the flap. As soon as the prominence of the heel has been passed, the difficulty of the operation is over. The assistant then puts the tendo Achillis on the stretch, and the surgeon divides this structure and continues to raise the flap from the posterior surface of the ankle-joint.

Fig. 247.—Syme's 'Foot-knife.' This is a strong-bladed knife with a stout back, so that there is not much risk of breaking the point when raising the flap.

When the heel flap has been raised to the level of the ankle-joint the surgeon takes charge of the foot himself, bends it forcibly downwards and proceeds to disarticulate from the front. This is done by deepening the original incision across the front of the instep, dividing the tendons and opening the joint. The lateral ligaments are next divided and finally the posterior ligament; the posterior tibial artery must be guarded from damage during the manipulations on the inner side.

An easier way of doing this very tedious operation is to deepen the dorsal incision directly it has been made, open the joint, disarticulate from the front, and separate the heel flap from above downwards instead of from below upwards.

After the foot has been removed, the soft parts are cleared from the lower end of the bones as far up as the level of the articular surface. In doing this, great care must be taken not to damage the posterior tibial artery and also not to button-hole the posterior flap, as is sometimes done by careless operators who double it up against the skin of the leg and forget it. A saw is then applied at right angles to the long axis of the leg just above the articular surface of the tibia. It is not necessary to remove the whole of the articular cartilage unless it be diseased. All

that is requisite is to saw off the malleoli. The leg is held horizontal by the assistant while the saw is being applied.

The vessels requiring ligature are the anterior tibial in the centre of the dorsal flap, the posterior tibial (or more probably its internal and external plantar branches) towards the inner edge of the heel flap, and one or two small vessels on the outer side. The anterior and posterior tibial nerves should be pulled out and divided high up. A small counter-opening is made in the centre of the heel flap for the insertion of a drainage tube ; this is very necessary, as otherwise the flap is certain to fill with blood, and healing may be interfered with. The wound is united by several stout interrupted stitches inserted at some distance from the cut edges so as to prevent any chance of the heavy heel flap becoming detached ; the union is completed by an ordinary continuous suture. The limb is placed upon a posterior straight splint with a special pad behind the heel flap so as to support it and press it forwards. When the case is aseptic the drainage tube may be removed after three or four days.

After-treatment.—In this amputation treatment must be continued after the wound has healed, because, owing to the weight of the flap, there is a considerable tendency to drag the scar over the front of the lower end of the bones. This would lead to a tender scar and interfere greatly with walking. The stump must therefore be bandaged as described on p. 502, so as to pull forward and fix the heel flap. After healing is complete, it is well to impregnate the bandage thus applied with starch so that it shall enclose the stump in a stiff unyielding case. The patient can usually begin to bear weight upon the stump in eight weeks ; before that time he can get about wearing a peg-leg.

Pirogoff's Amputation.—Syme's amputation has been modified by Pirogoff who saws through the os calcis ; the posterior portion of the bone is left behind in the heel flap. Pirogoff's operation, however, is unsuitable for any but a few rare cases. It is very troublesome to perform, and its results are not materially better than those obtained from Syme's amputation, whilst instrument-makers rather object to it on account of the greater difficulty experienced in fitting an artificial foot. We shall therefore not describe the operation.

AMPUTATION THROUGH THE ANKLE BY AN INTERNAL FLAP.

In some cases Syme's amputation may with advantage be abandoned in favour of a somewhat similar one in which the posterior is replaced by an internal flap. On the whole, this operation is inferior to Syme's, because the skin in this situation is not so fitted for bearing pressure as is that over the heel. Nevertheless it gives a good result, as the skin becomes thickened and capable of bearing pressure after a time. The incision commences at the tip of the external malleolus and runs across the front of the ankle with a slight convexity downward until it reaches

the astragalo-scaphoid joint. From this point it passes straight on to about the centre of the sole, whence it turns backwards, passing over the centre of the heel to the level of the upper surface of the os calcis ; it is then carried round the outer side of the ankle to join the commencement of the incision beneath the external malleolus (see Fig. 248). The large internal flap thus marked out is raised from the bone, with which the edge of the knife is kept in contact throughout. The raising of the flap has to be effected with the greatest circumspection, as its nutrition is essentially derived from the posterior tibial artery, and therefore any injury to that vessel or its branches higher up than the point of section in the incision will materially damage it. When the ankle-joint has been exposed, the foot is disarticulated and the lower ends of the tibia and fibula are cleared, and the malleoli sawn off just as in Syme's amputation. The cicatrix lies along the outer side of the stump, and the patient walks upon skin that is partly derived from the sole and partly from the inner side of the foot. In cases of tuberculous disease of the ankle this operation has the advantage that the synovial membrane is more easily removed along with the foot, and therefore there is not the same risk of recurrence in the stump.

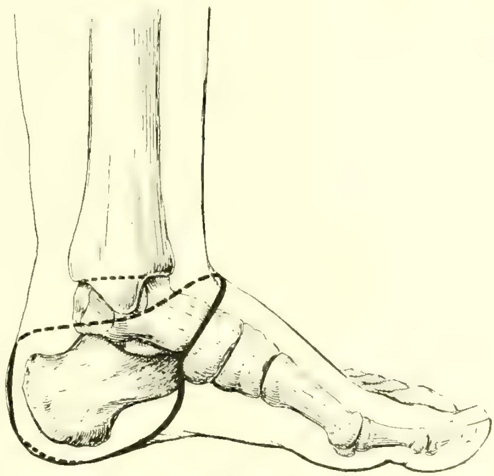

Fig. 248.—Amputation at the Ankle-joint by an Internal Flap. The thick continuous line shows the incision upon the inner aspect of the foot, that on the outer being denoted by the thick dotted line. The thin dotted line on the bone shows the level of the bone section if the cartilage be healthy ; otherwise it is well above this level.

AMPUTATIONS THROUGH THE LEG.

The general rule that the greatest possible amount of bone should be left in the stump, applies to amputations through the leg as to amputations elsewhere. Formerly the custom was to divide the bone at what was termed the ' seat of election,' namely, about a hand's breadth below the top of the tibia. The reason for this was that pressure was borne upon the bent knee, which was received into what was termed a bucket stump, and the bones of the leg were therefore intentionally cut short, so that there should be no undue projection behind. The fitting of artificial limbs has been so much improved of late years, however, that

the natural movements of the knee-joint can be utilised; hence the longer the limb the better the leverage that the patient can bring to bear upon the artificial limb.

LISTER'S AMPUTATION THROUGH THE LEG.

The best amputation through the lower third of the leg is that described by Lord Lister in Holmes' *System of Surgery*, Vol. III. p. 717 (see Fig. 249). His description is as follows:—

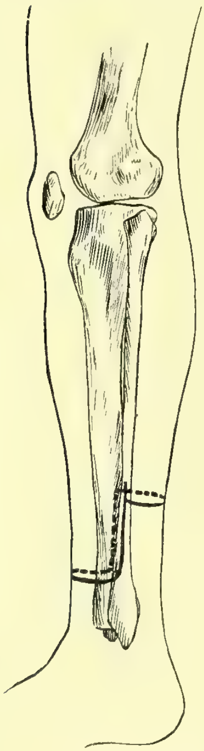

FIG. 249.—LISTER'S AMPUTATION THROUGH THE LEG. The vertical incision over the fibula extends about an inch higher up the limb than the corresponding one on the inner side.

'The diameter of the limb having been ascertained by spanning it, a straight longitudinal incision of that length is made at the inner side of the leg, and on the outer aspect another similar incision directly over the fibula and extending about an inch higher up. The lower ends of these incisions are connected by cutting across the front of the limb in a direction transverse in the main, but rounded off where it joins the lateral lines. The knife is next carried round the back of the limb to the bone from the upper end of the internal incision to a point exactly opposite on the outer side, which will be about an inch below the upper end of the outer incision, the instrument being carried in a line slightly convex downwards so as to form a very short posterior flap. The anterior flap is then raised in the manner above mentioned (by peeling up the tissues with the thumb) including everything in front of the bones and interosseous membrane, after which the tibia and fibula are cleared as high as the level of the upper end of the outer incision, the finger-tip being still used in detaching the parts anterior to the interosseous membrane. In order to avoid splintering the fibula, it is best to saw both bones at the same time, and to finish the fibula before the tibia. The sharp angle of the spine of the tibia, being apt to cause ulceration of the skin over it, should be removed; and the most convenient way of doing this is to commence with sawing obliquely for a short distance from a point about half an inch above the place where the bones are to be divided transversely (see Fig. 227, *A*).

'Supposing effectual antiseptic treatment be employed, the cutaneous margins of the flaps may be stitched very closely, except at the upper

end of the outer incision, which is left open for the drain, and serves admirably for the purpose, as it leads directly from the cut surfaces of the bones and is dependent in position, from the circumstance that the limb reposes on its outer side. Accurate stitching is desirable elsewhere in consequence of the disproportion of the sizes of the two flaps which, however, is diminished by making a short posterior flap as advised.'

In raising the anterior flap, care must be taken to avoid damage to the anterior tibial artery which lies immediately upon the front of the interosseous membrane. Therefore the knife must not be used more than is absolutely necessary in this situation, and the tissues should be peeled off the membrane by means of the fingers or the handle of the knife. Before sawing the bones the interosseous membrane is divided with the knife. If the end of the tibia be rounded off, as directed above, the stump soon becomes able to bear considerable pressure, as the skin over the ends of the bones becomes thickened and closely resembles that upon the sole of the foot. The cicatrix is pulled well up out of the way behind by the contraction of the posterior muscles.

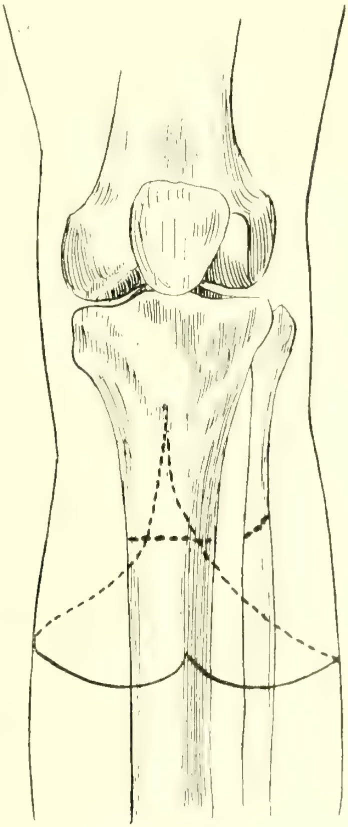

FIG. 250.—AMPUTATION OF THE LEG AT THE 'SEAT OF ELECTION' BY THE 'HOODED FLAP.' The dotted line across the tibia shows the level at which the bones are divided. It will be seen that the incision shown above is notched in front, and does not run transversely across the limb as described in the text. The notching facilitates the raising of the flaps, and may be used when a bucket stump is to be worn.

AMPUTATION AT THE 'SEAT OF ELECTION.'

Here the bones are usually divided about a hand's breadth below the top of the tibia. Various operations have been described, the one that we prefer being by means of a '*hooded flap*' fashioned somewhat after the manner of Stephen Smith's flaps for amputation at the knee-joint (see p. 545). The operation is performed as follows: The surgeon, standing upon the patient's right side, places his left thumb upon the crest of the tibia at the spot at which he desires to divide the bones, whilst the forefinger is placed in the centre of the calf about three inches higher up.

Bending over the limb, he introduces the knife in the middle line of the calf just below the spot marked by his forefinger, and carries an incision almost vertically downwards, or with a very slight divergence to the side of the limb opposite to that on which he stands, to about two inches below the spot at which the bone is to be divided. The incision is then carried almost transversely across the front of the limb to a corresponding spot on the other side, whence it ultimately passes upwards to join the vertical incision in the calf (see Fig. 250). To enable the surgeon to mark out the last part of the incision the limb must be raised almost to the vertical. It is well to cut the flap somewhat longer on the inner side of the limb than on the outer. In this way a racket-shaped or oblique flap is fashioned, the lower end of which is about two inches below the point of bone section. This flap is then raised, the muscle being taken up with it, and also, should it be healthy, the periosteum ; the bones are sawn at the point previously determined, and the crest of the tibia is bevelled off. The result is that a hood of skin and muscle falls over the ends of the bones, whilst the cicatrix lies vertically just behind them. As the contraction incidental to healing takes place, the scar becomes pulled up behind the bones and out of harm's way.

Amputation at this situation may also be done by means of *lateral flaps* in which the cicatrix falls over the ends of the bones. This method should only be employed when the old bucket-stump is to be used, as then there will be no pressure upon the ends of the bones, and the position of the cicatrix therefore is unobjectionable. In fashioning lateral flaps the one on the inner side must be cut longer than the outer to allow for the greater width of the tibia. In other cases the operation may be performed by means of a single *large external flap* as described by Farabeuf, but when the surgeon has the choice we prefer the hooded flap above described.

Other Methods.—It used to be the fashion to amputate the leg by transfixion and to provide a long posterior and a short anterior flap, the former being the length of the diameter of the limb where the bones were divided, while the anterior flap was about one-third as long. The objection to this is that the weight of the posterior flap drags upon the line of union, and this either gives way or the scar is pulled down till it lies over the ends of the bones. The latter objection was no great disadvantage when amputation was performed at the 'seat of election,' because no pressure was to be borne upon the end of the stump, but at the present time it should not be performed except when, owing to destruction of the skin on the front of the limb, it is necessary to make a long posterior flap in order to save the movements of the knee-joint. Even when performed under these circumstances, it is better to cut the posterior flap from without inwards rather than by transfixion, and to take up only a comparatively small amount of muscle in it.

DISARTICULATION AT THE KNEE-JOINT.

Disarticulation at the knee-joint is most frequently required for malignant disease of the tibia, for injuries in which the condition of the parts does not allow of an amputation through the leg, and for gangrene of the foot when the tibial arteries are blocked. Whenever it is possible to obtain sufficient soft parts to cover in the condyles of the femur, disarticulation is always preferable to amputation through the lower end of the bone, because the broad smooth condylar surfaces are most admirably adapted for bearing pressure. Instrument-makers rather object to amputations through the joint because they bring the new knee-joint in the artificial limb to a somewhat lower level than on the opposite side, but as a compensation for this we have a stump upon which the full weight of the patient can be borne without any trouble.

In our opinion the best operation is that introduced by Stephen Smith, and often called the method by a 'hooded flap.' It is performed as follows: The patient lies upon his back with the sound leg flexed at the knee, and tied to the leg of the table so as to be out of the way of the surgeon, and with the limb on the affected side projecting well beyond the edge. The leg is fully extended and is held horizontally by an assistant, whilst the surgeon, standing on the patient's right, first defines with the left thumb and forefinger the tubercle of the tibia in front, and a spot in the middle of the popliteal space behind opposite the level of the knee-joint. The assistant then rotates the limb towards the surgeon, who bends over and enters the knife behind at the spot fixed in the popliteal space, and carries an incision vertically downwards for about a couple of inches, and then gradually sweeps downwards and forwards round the side of the limb furthest away from him, cutting a rounded flap with its convexity downwards and crossing the middle line an inch below the tubercle of the tibia. From this point the knife is drawn across the side of the limb nearest the surgeon, also in a curve with its convexity downwards, and is carried obliquely upwards and backwards over the posterior surface to join the lower end of the vertical portion of the original incision (see Fig. 251, *A*). During the latter part of the procedure the limb is raised to the vertical position and rotated away from the surgeon. Instead of bringing the incision transversely across the limb, it is well to make it run somewhat obliquely, so that the flap on the inner side is rather longer than that upon the outer, on account of the larger size of the internal condyle of the femur. It is also well to notch the flap in front by carrying the incision almost up to the tubercle of the tibia and down again to its original level on the opposite side (see Fig. 251, *A*). This is not essential, but it gives a neater stump, and one which is easier to suture afterwards.

The assistant now flexes the knee, whilst the surgeon raises the flap, which for the first inch should consist only of skin and subcutaneous

tissues. After this, all the tissues should be taken up down to the bone. When the ligamentum patellæ is exposed, it should be divided immediately above the tubercle of the tibia and the dissection is then carried upwards all around the bone until the upper margin of the tibia is reached. The knife is now introduced between this bone and the semilunar cartilages, and made to detach the latter and leave them in contact with the condyles of the femur. The tendons and ligaments about the front and lateral aspects of the joint are divided, when, by increasing the flexion of the limb, the surgeon is able to complete the separation of the semilunar cartilages from the head of the tibia and to divide the crucial and the

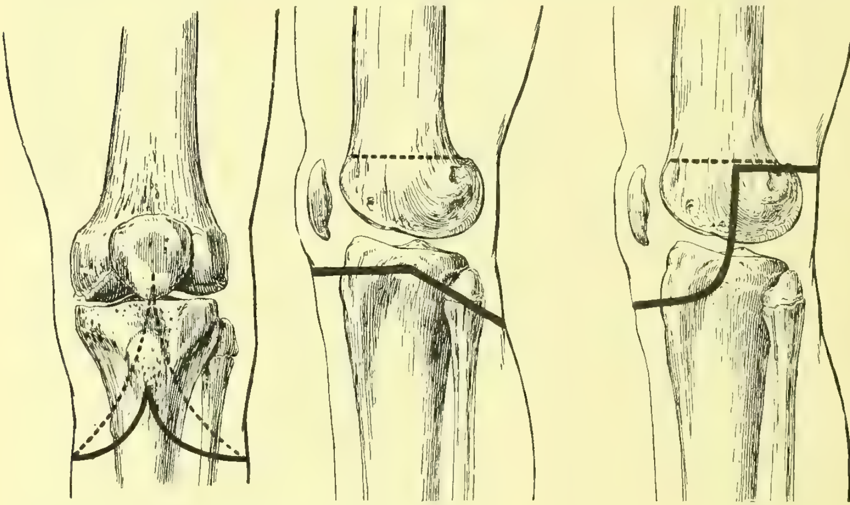

FIG. 251.—AMPUTATIONS ABOUT THE KNEE.
A. Stephen Smith's 'hooded flap' method of disarticulation at the joint. In the original operation the incision ran transversely across the front of the limb, and was not notched as depicted above.
B. Lister's modification of Carden's amputation.
C. Carden's amputation through the femoral condyles.
In the last two operations the dotted line indicates the level at which the bone is divided.

posterior ligaments. The division of the hamstring tendons and the popliteal vessels and nerves completes the disarticulation. In order to do this the assistant brings the leg nearly into line with the femur, and keeps the flaps out of the way, while the surgeon cuts vertically downwards through the joint. The arteries requiring ligature are the popliteal, which with its vein will be found in the middle line behind the femur, and the anastomotica magna on the inner side of the flap; a few other ligatures will be required for articular and muscular arteries. The patella is left undisturbed in the flap.

A drainage tube should be inserted at the posterior extremity of the wound and may be removed after two or three days. The limb is placed

in a short trough of Gooch's splinting, elevated and secured to an inclined plane or firm pillow.

This operation gives a large hooded flap which falls over the end of the femur, and the skin of this flap is dense and able to bear considerable pressure. The cicatrix is vertical, and lies partly behind the femur and partly in the hollow between the condyles. As healing goes on, it gets more drawn up upon the posterior aspect of the thigh out of the way of all pressure. The object of leaving the semilunar cartilages behind is to form a natural pad to the rounded condyles, so that the end of the stump presents a level surface well adapted to bear pressure. It is found in practice that the result is much more satisfactory when the cartilages are left behind than when they are taken away.

AMPUTATIONS THROUGH THE CONDYLES OF THE FEMUR.

Various amputations are performed in this situation in which the line of bone section is through the condyles of the femur. This may be necessary, for example, when malignant disease of the tibia extends so high up that it is impossible to get sufficient covering after disarticulation, or when there is disease of the knee-joint itself ; it may also be called for in severe injuries or septic troubles, such as extensive necrosis of the leg.

LISTER'S MODIFICATION OF CARDEN'S AMPUTATION.

Carden's amputation is often performed at the present day, but in our opinion the modification suggested by Lord Lister in *Holmes' System of Surgery*, Vol. III. p. 718, is preferable. The disadvantage of Carden's operation is that sloughing may occur in a portion of the long anterior flap, and it is evident that this risk will be diminished if the flaps be made shorter by not carrying the horns of the incision so high up the limb on each side. Lister's amputation is performed as follows :—

'The surgeon first cuts transversely across the front of the limb from side to side at the level of the anterior tuberosity of the tibia, and joins the horns of this incision posteriorly by carrying the knife at an angle of 45° to the axis of the leg through the skin and fat [see Fig. 251, *B*]. The limb being elevated, he dissects up the posterior skin flap, and then proceeds to raise the ring of integument as in a circular operation, taking due care to avoid scoring the subcutaneous tissue ; and, dividing the hamstrings as soon as they are exposed, and bending the knee, he finds no difficulty in exposing the upper border of the patella. He then sinks his knife through the insertion of the quadriceps extensor, and having cleared the bone immediately above the articular cartilage, and holding the limb horizontally, he applies the saw vertically and at the same time transversely to the axis of the limb (not of the bone), so as to insure a horizontal surface for the patient to rest on. The popliteal artery and

vein are then secured, and any articular or other small branches that may require it.

'When the soft parts are thickened and condensed by inflammation, the integument cannot well be reflected above the patella with such incisions of the skin. But the difficulty may be got over by cutting into the joint as soon as the ligamentum patellæ is exposed, and at once removing the leg by dividing the ligaments and hamstrings, after which the soft parts can be retracted from the femur sufficiently to permit the application of the saw. The arteries having then been secured, the patella is dissected out at leisure.'

This amputation takes a little more time and is a little more difficult than Carden's, but any extra trouble is amply repaid by the good covering to the bone, the small external wound, and the perfect security against sloughing.

CARDEN'S AMPUTATION.

In Carden's original amputation a long anterior flap was formed by cutting downwards from the point at which the condyles of the femur are to be divided on the one side of the joint to below the level of the patella, and then bringing the incision across the front of the limb and up to a corresponding point upon the opposite side (see Fig. 251, *C*). The patella should be raised with this flap. When the flap has been reflected to the point of section of the condyles a transfixion knife is passed close behind the bone at that spot, and by a steady sweeping cut the soft parts and the skin are divided at right angles to the long axis of the bone, so that no posterior flap is made. The bone is then cleared at the proposed point of division, and the condyles removed by the saw which is applied at right angles to the long axis of the limb.

THE STOKES-GRITTI AMPUTATION.

The object of sawing the femur through the condyles is to furnish the patient with a broad flat surface upon which pressure may be borne. For the better accomplishment of this object it has been proposed to saw off the cartilaginous surface of the patella and to apply the cut surface thus made to the cut surfaces of the condyles. This procedure is known by the name of the Stokes-Gritti operation, but it does not present any advantages which counterbalance the increased time and patience required for its performance. It is difficult to cut off the cartilaginous surface of the patella completely and to apply it accurately to the sawn surface of the femur; and it is often very difficult, after this has been done, to secure it in position satisfactorily, and to prevent it being tilted away from the bone by the pull of the quadriceps extensor muscle. For these reasons we cannot recommend the operation and shall therefore not describe it. Its results are in no way better than those of the amputations already described.

AMPUTATIONS THROUGH THE SHAFT OF THE FEMUR.

Amputation may be practised anywhere through the shaft of the femur. The usual situation is either at or below the middle of the bone, amputation in the lower third being especially suitable for tuberculous disease of the knee-joint.

AMPUTATION BY ANTERO-POSTERIOR FLAPS.

In this situation the best operation is by means of antero-posterior flaps, but lateral flaps may be employed when there is not sufficient sound skin available for an anterior one ; even the circular method may be adopted. A good result may also be obtained by antero-external and postero-internal flaps. It should be remembered in amputating through the femur that it is not necessary to sacrifice bone in order to insure the cicatrix being out of the way of its divided end, because very little weight, if any, is borne upon the end of the stump when an artificial limb is fitted, as this takes its support mainly from the pelvis. The length of the femur left is of great importance ; the function of the stump is not to carry weight, but to form a lever to work the artificial limb, and therefore the longer the lever the more satisfactory is the result. At the same time, the scar should not lie directly over the end of the bone if it can be avoided ; in any case it is necessary to pull out the nerves and cut them short, so that their ends cannot become involved in the cicatrix. The operation used frequently to be done by transfixion, and some surgeons still prefer to cut the anterior flap from without inwards and the posterior one by transfixion. There is no great objection to this, but the flaps are more accurately fashioned if they are cut from without inwards.

Preliminary Precautions.—In all these cases the surgeon must take every possible precaution to prevent *shock* (see Vol. I. p. 117), not the least valuable of which is rapidity of operation. The special measures for ensuring the *prevention of hæmorrhage* in operations in this situation have already been dealt with fully (see p. 495). If due precautions be taken it is remarkable how slight the shock often is.

AMPUTATION BY ANTERO-EXTERNAL AND POSTERO-INTERNAL FLAPS.

The operation which we prefer in all cases where choice is possible consists in making a flap on the anterior surface of the limb which shall be slightly antero-external rather than directly anterior ; in length this flap should be about seven-eighths of the diameter of the limb at the point where the bone is to be divided. The object of having the flap somewhat external is to prevent the angle of union of the flaps lying over the femur, which is liable to be the case when the flaps are anterior and posterior. Moreover, it ensures the femoral artery lying in the posterior flap, and not in the angle between the flaps when the amputation is at

or above the middle of the thigh. The posterior flap should be about a third as long as the anterior one and both should consist merely of skin, subcutaneous tissue, and deep fascia for the first two or three inches ; then a gradually increasing thickness of muscular tissue should be taken up as they are raised, as has already been described for the mixed-flap method (see p. 498).

While sawing the femur, care must be taken to keep the limb horizontal and perfectly steady, and the bone should be divided at right angles to its long axis. Special care must be taken when finishing the division of the linea aspera, for the saw is apt to become locked if the assistant does not keep the limb steady, or else the bone may be fractured before it is completely divided. Should the latter event happen, the sharp edge of the linea aspera must be snipped off with bone forceps or rounded off with a saw (see Fig. 227, *B*).

A large drainage tube should be inserted at the outer angle of the wound, whilst the limb is laid in a trough of Gooch's splinting supported upon an inclined plane ; both the dressings and the splint should be fastened round the pelvis by a spica bandage. It is essential to elevate the limb in order to relax the quadriceps extensor muscle, which would otherwise pull injuriously upon the anterior flap.

This method of amputation by means of long anterior and short posterior flaps, or by antero-external and postero-internal ones, is applicable to almost any part of the thigh, and the exact position and length of the flaps can be varied according to the circumstances of the case. But irregular operations should always be performed in preference to removing an unnecessary amount of bone. Almost the only amputation which is unsuited for the thigh is that by means of a long posterior flap.

DISARTICULATION AT THE HIP-JOINT.

These were formerly among the most fatal and unsatisfactory operations which the surgeon was called upon to perform. The danger was due partly to the loss of blood at the time, partly to the profound shock occasioned by the division of large and important nerve trunks, and also in large degree to the septic infection of the wound which so constantly occurred afterwards. At the present time these dangers have much decreased, owing partly to improvements in the methods of operation and partly to the profound alteration in the treatment of wounds. The result is that, except when the operation is done for injury, the mortality is extremely slight if the patient be in good health when the operation is performed. The bleeding can be controlled satisfactorily, and the soft structures may frequently be divided comparatively low down in the thigh and the head of the bone subsequently dissected out, so that the large nerve trunks are divided at a much lower level than formerly, and the shock is

thereby much diminished. It is also a debated point at the present time whether the shock due to the division of the large nerve trunks may not be greatly decreased by the substitution of spinal analgesia for general anæsthesia (see Vol. I. p. 486). At any rate, it is well to try this in cases of primary amputation in the region of the hip for severe injury. Besides this, the flaps can be so planned that the line of incision is at a considerable distance from all sources of sepsis, which, combined with the improved antiseptic arrangements now in vogue, renders the avoidance of septic infection fairly certain.

Disarticulation at the hip-joint has to be performed under two different sets of conditions. In the one case the nature of the disease permits of the formation of long flaps, whilst in the other the flaps have to be short. We shall describe operations suitable for each of these two main indications. The operation is generally required for tumours of the femur, but it may also be necessary in bad crushes of the limb, especially when the thigh is torn off ; it may be called for in widespread necrosis or extensive tuberculous disease of the femur, while some surgeons perform it for bad hip-joint disease, where the trouble has extended on to the ilium or where there is lardaceous disease—in some instances with considerable benefit.

FURNEAUX JORDAN'S OPERATION.

This is the most suitable operation for all those cases in which it is possible to form long flaps. It consists essentially of a circular amputation of the limb well below the trochanters, and subsequent enucleation of the upper end of the bone. The vessels and nerves are divided low down, so that bleeding and shock are less severe, and the angle of the wound is at a considerable distance from any possible source of contamination.

The Operation.—Towels are arranged so as to cover the whole of the lower part of the abdomen, the buttocks, and the perineum, and the most scrupulous care is taken to disinfect the limb, especially about the folds of the perineum. The femoral vessels are controlled (see p. 495), and the point at which the bone is to be divided is determined upon. A circular incision, somewhat notched at the inner side, is then made around the thigh about an inch below this point (see Fig. 252, *A*). This notch on the inner side is made to enable the flaps to be raised with greater ease and to be more satisfactorily sutured afterwards. The incision goes through the skin, fat, and fascia, which are now dissected up for about two inches. The muscles are next divided circularly down to the bone, retracted carefully and the bone is sawn.

The next step in the operation is to secure the principal vessels, and then a vertical incision is carried up over the outer side of the femur from the circular incision to a point midway between the crest of the ilium and the top of the great trochanter, and deepened down to the bone from which

the soft parts are rapidly dissected off. It is quite safe to remove the tourniquet at the end of the circular amputation after the principal vessels have been clamped. There is little bleeding in the later stages of the operation, any large vessels divided being clamped at once. It is usual, when the circumstances of the case allow it, to carry the incision right down through the periosteum, which is stripped off from the bone along with the soft parts. The flaps are held well apart, and the head of the bone is rapidly disarticulated and removed. Some surgeons

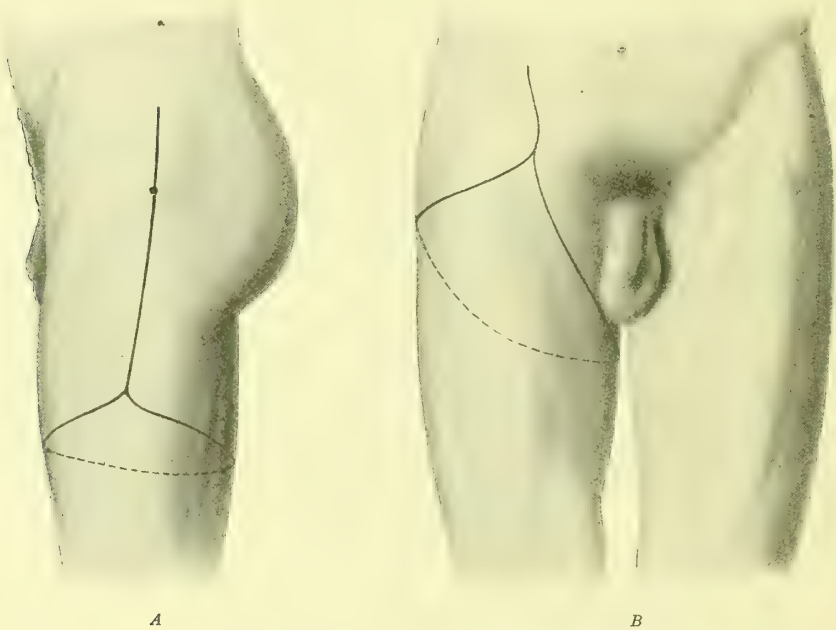

FIG. 252.—DISARTICULATIONS THROUGH THE HIP-JOINT.

A. Furneaux Jordan's Operation.—The circular amputation is done first. The vertical incision is then added, and the upper end of the bone enucleated. The vertical incision is usually about eight or nine inches long and runs up about two inches above the top of the great trochanter, which is marked by a dot in the figure; a second dot is placed upon the crest of the ilium.

B. Disarticulation by Oval Flaps (anterior racket). The vertical incision is made first and lies over the femoral vessels. The outer portion of the racket incision should cross the limb just below the base of the trochanter.

do not saw the bone after the muscles have been divided in the circular amputation, but make use of the intact femur to aid the manipulations necessary for disarticulation. It is immaterial which method is employed.

When all bleeding has been arrested, a large drainage tube leading down to the acetabulum is inserted at the upper and outer part of the wound, and the rest of the incision is sewn up. In order to prevent the dressings slipping, it is well to fasten the inner side to the perineum by

means of a layer of dry gauze and collodion, or by rubber strapping (see p. 501), and it is also very important to cover the inner aspect of the dressing with mackintosh in order to prevent it from being soiled. The best way to do this is to take a piece of mackintosh long enough to surround the thigh and broad enough to reach from the perineum down to the end of the stump. The edge of the mackintosh is then fixed to the skin of the perineum by means of a broad strip of adhesive plaster, and the same thing is done above and behind, and thus the mackintosh is firmly fixed. A trough of Gooch's splint should be applied, and it and the bandages fastened on by a spica ; the lower end of the splint is raised and secured to a firm pillow.

The dressing must be changed on the following day on account of the free oozing that will occur. Subsequent changes of dressings will be called for according to the amount of discharge ; it is better to err on the side of changing the dressings too frequently than to do it too seldom. As a rule it will be found necessary to dress the stump every day for the first three or four days. The drainage tube may usually be left out in about a week.

THE ANTERIOR RACKET OPERATION.

This type of operation is the one generally called for in cases of malignant tumour of the femur. The flaps have to be short, and therefore the vessels and nerves are divided higher up than in the previous operation.

A vertical incision nearly six inches long beginning an inch above Poupart's ligament is first made over the common femoral vessels, which are tied and divided between ligatures. This incision is then prolonged obliquely around the thigh, crossing its inner aspect a full hand's breadth below the perineum and its outer aspect just below the base of the great trochanter (see Fig 252, *B*). The skin and fascia alone are first divided and dissected up for about two inches. The muscles on the inner side are then cut across as close to the pelvis as possible when the tumour is high up. The ligatured and divided ends of the common femoral artery and vein must be pushed well up out of the way of injury when this is being done. This exposes the inner aspect of the capsule and neck of the femur. The former structure is opened by a free incision through it and the cotyloid ligament parallel with the long axis of the neck, and the head of the bone is then rapidly disarticulated and pulled forcibly forward. This gives access to the muscles in the buttock and the outer flap, which are divided obliquely in the line of the incision by a few strokes of the knife. The only vessels requiring ligature will be branches of the gluteal and sciatic, and the amount of blood lost is quite small. When it is very important to reduce bleeding to a minimum—as for example when there

is a large vascular growth—it will probably be safer and more expeditious to ligature the common iliac artery (see p. 224) as a preliminary measure. Spinal analgesia will also be useful in lessening shock. If general anæsthesia be used, it may diminish shock to some extent if a few drops of a 5 per cent. solution of cocaine are injected into the substance of the great sciatic nerve well above the point of section a few minutes before this structure is divided.

A large drainage tube should be placed in the lower and outer angle of the wound, and the dressing should be fixed on, and the mackintosh and splint applied as above described.

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